(Established 1832).

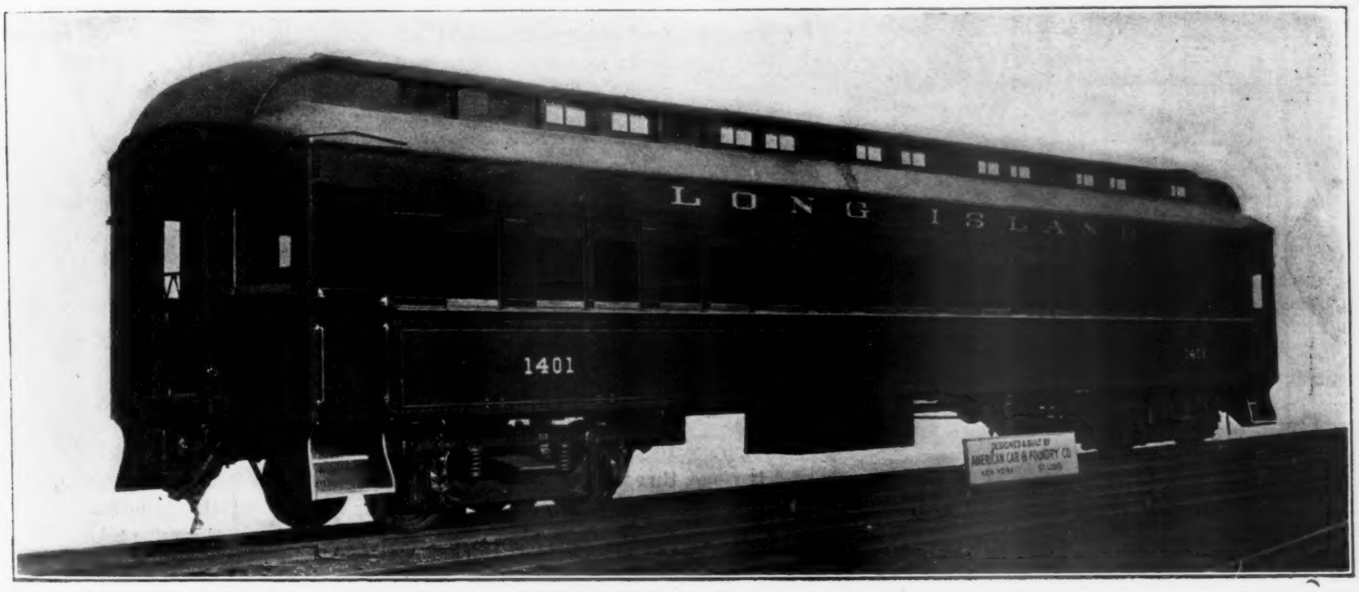
AMERICAN ENGINEER AND RAILROAD JOURNAL.

FEBRUARY, 1907.

STEEL PASSENGER CAR.

LONG ISLAND RAILROAD.

The American Car & Foundry Company has recently designed and built a sample all-steel passenger coach for the Long Island Railroad. This car is constructed to give the same floor plan as the present Pennsylvania standard passenger car, and will seat 72 persons. It is practically all steel throughout, the only wood found in the construction being a small amount used for holding a part of the interior finish. Its length over buffers is 67 ft. 4¼ ins., and its total weight in running order is 94,500 lbs.



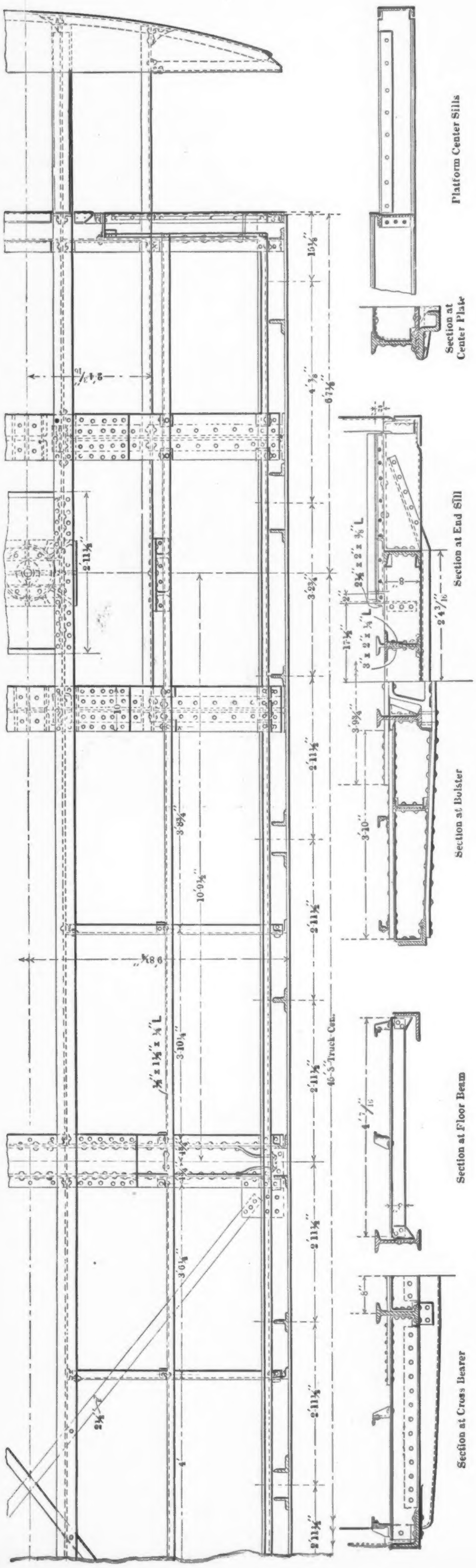
STEEL PASSENGER COACH—LONG ISLAND RAILROAD.

The primary considerations in designing this car were: First, to make it absolutely fireproof; second, to so arrange the construction as to make it as strong, or stronger in collision, than any passenger car now running, and, third, to make it as light in weight as the other considerations would permit. Special care was also given to making both the exterior and interior of as pleasing an appearance as possible. That all of these problems have been successfully solved is evident from a careful inspection of the illustrations shown herewith. It is evidently fireproof, as there is nothing combustible in its construction. To withstand ordinary buffing strains and shocks due to collisions, the car is equipped with Westinghouse friction draft gear and the Gould friction buffer, which have a combined capacity of something over 300,000 lbs.; and the center sills, consisting of 10-in. I beams which are continuous from buffing beam to buffing beam; and the platform I beams extending from the buffing beam through both members of the double bolster and tied together by ¼-in. steel plates riveted to the top flanges and used as platform floor plates. In addition to these the diaphragms are so arranged that the side girders of the car will also assist the center sills to withstand any shocks. Furthermore, from a study of the design it will be seen that the vestibule and roof construction are such as to prevent a collapse of the body in case of a corner blow or of overturning upon an embankment. The design of the hood is such that should it become distorted by reason of a collision it can be removed without disturbing the main members of the body framing. By reference to the drawings it will be seen that the body end carline is double and the purlines and rafters are not continuous, the two angle irons forming the body end carlines being held together by rivets passing through spacing thimbles, the eaves angles and side plate angles being the only continuous members connecting hood to body framing.

In the matter of weights it is interesting to note that this car weighs, exclusive of the storage batteries, but 1,233 lbs. per seated passenger, while one of the modern wooden coaches on the P. R. R., which does not carry storage batteries, weighs 1,363 lbs. per seated passenger. That car is 5 ft. 3¼ ins. shorter than the Long Island car and seats but 62 persons. The excellent appearance of both the exterior and interior of the car is shown in the reproductions from photographs.

In general, the scheme of design is to support the whole weight of the car body from two girders, which form the sides of the car below the window sills. These girders are in turn supported by the large double bolsters, which carry the weight to the center plate through a short section of the center sills. The weight of the roof, vestibules, floor, center sills and live

END OF STEEL PASSENGER COACH.



UNDERFRAME OF LONG ISLAND STEEL PASSENGER COACH.

load are all transferred to the side girders by means of the side posts, cross bearers and end sills.

These side girders consist of a 3-16-in. web plate forming the side of the car below the windows and a tension member, consisting of a 6 x 6-in. angle iron, which forms the side sill of the car. The compression member of the girder, which becomes the tension member for a short distance over the bolsters, consists of two pieces, a specially rolled bulb angle on the outside and a 7-16 x 3-in. continuous steel bar on the inside of the plate, the two being securely riveted together with the plate between them. The web of the girder is stiffened by the side posts of angle and T irons, which are offset at the bottom and top to clear the lower angle and the upper bar, and are securely riveted to both the plate and the other members. The whole girder is stiffened sidewise by the cross bearers, of which there are three, the end sills, floor beams, and by the carlines acting through the side posts.

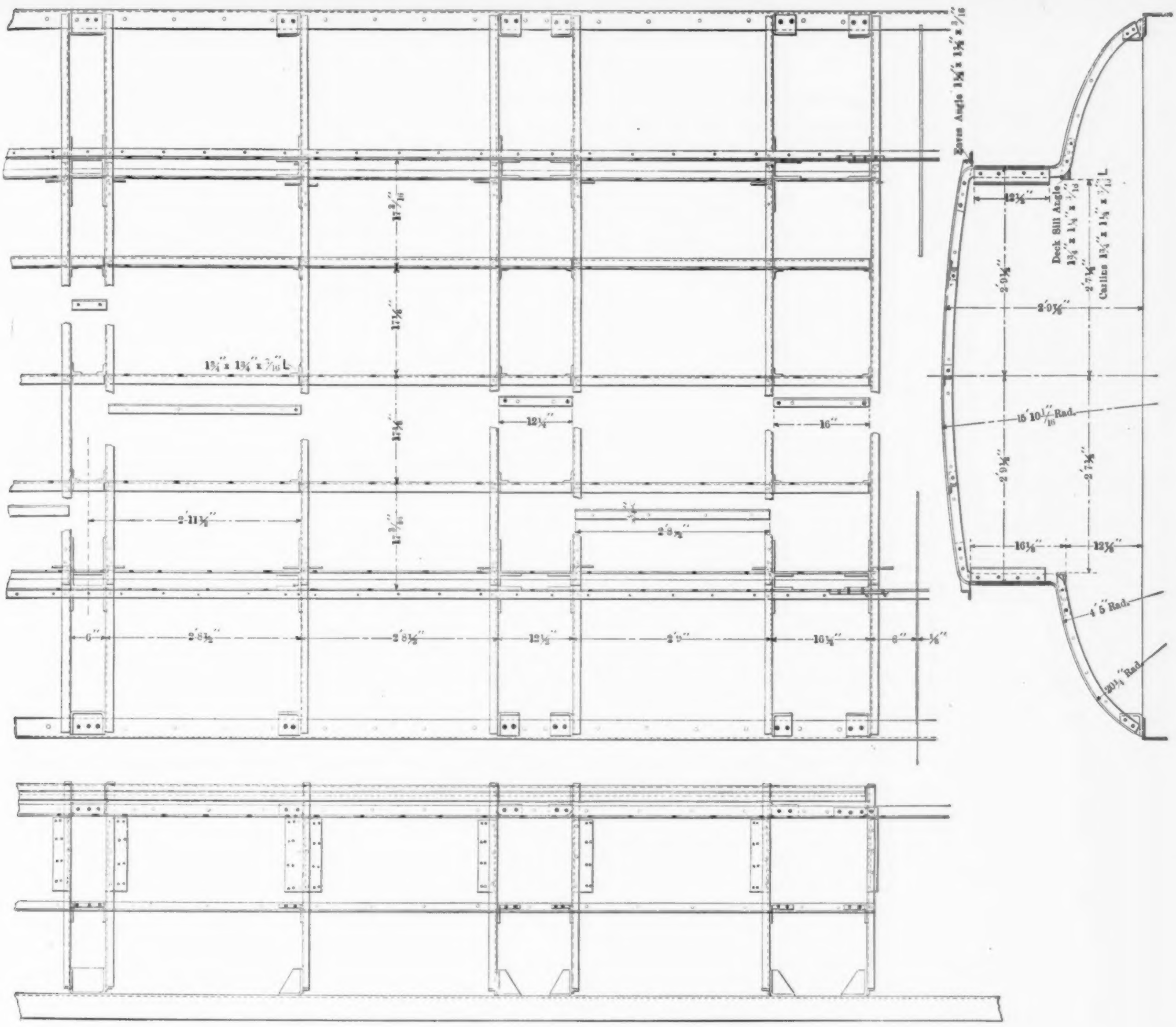
The weight of the vestibule is carried quite largely by its roof construction, which transfers the load through the corner posts and door posts, and thence by the end sills to the side girder. The weight of the platform, which also includes some of the vestibule, is carried by two auxiliary or intermediate sills, consisting of 8-in. channels, which are supported at the end sill and transfer their weight by that means to the side girders. These also extend inward, and are connected to both sections of the bolster.

The general features of the construction of the whole car are very clearly shown by the illustrations, and it will not be necessary to consider them in any great detail. The following general description, however, will be given largely as a supplement to the drawings:

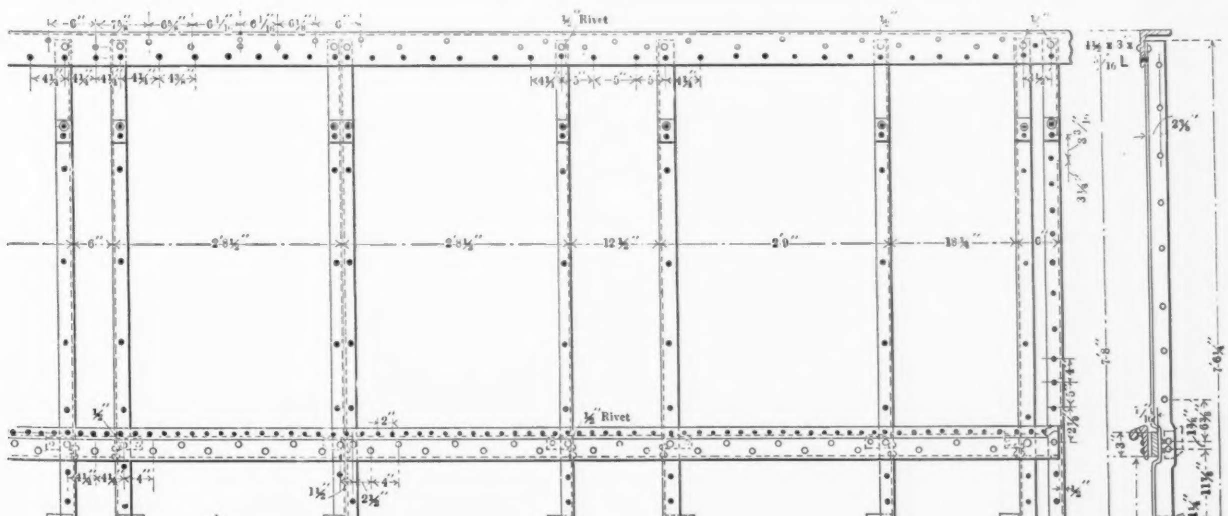
The underframe comprises the 6 x 6-in. angles forming the lower part of the side girder, which act as side sills. The 10-in. I beams set at 16-in. centers act as center sills. The three cross bearers are equally spaced between the bolsters, and a pair of diagonal braces connect at the junction of the cross bearers and side sills by means of gusset plates. The floor, which is formed of "Acandlith" cement spread on corrugated sheets of galvanized iron, made of a special keystone section, is supported on the center sills and by longitudinal angles resting on the cross bearers and bolsters, there being one at the side posts and one intermediate between that and the center sills. These longitudinal angles are further supported by the floor beams connecting between the center and side sills, and consisting of 3-in. angles. This construction leaves an open space of about 3½ ins. below the floor, in which cables, pipe lines, etc., can be installed without difficulty, if desired.

The cross bearers consist of flange plates placed between the side and center sills and riveted thereto, as well as a spacing plate of similar construction between the center sills, below which there is a special trough section, which is continuous from side to side of the car below the center sills and is securely fastened to the side sills. A short cover plate is passed through the web of the center sills and riveted to the outstanding flanges of the side fillers.

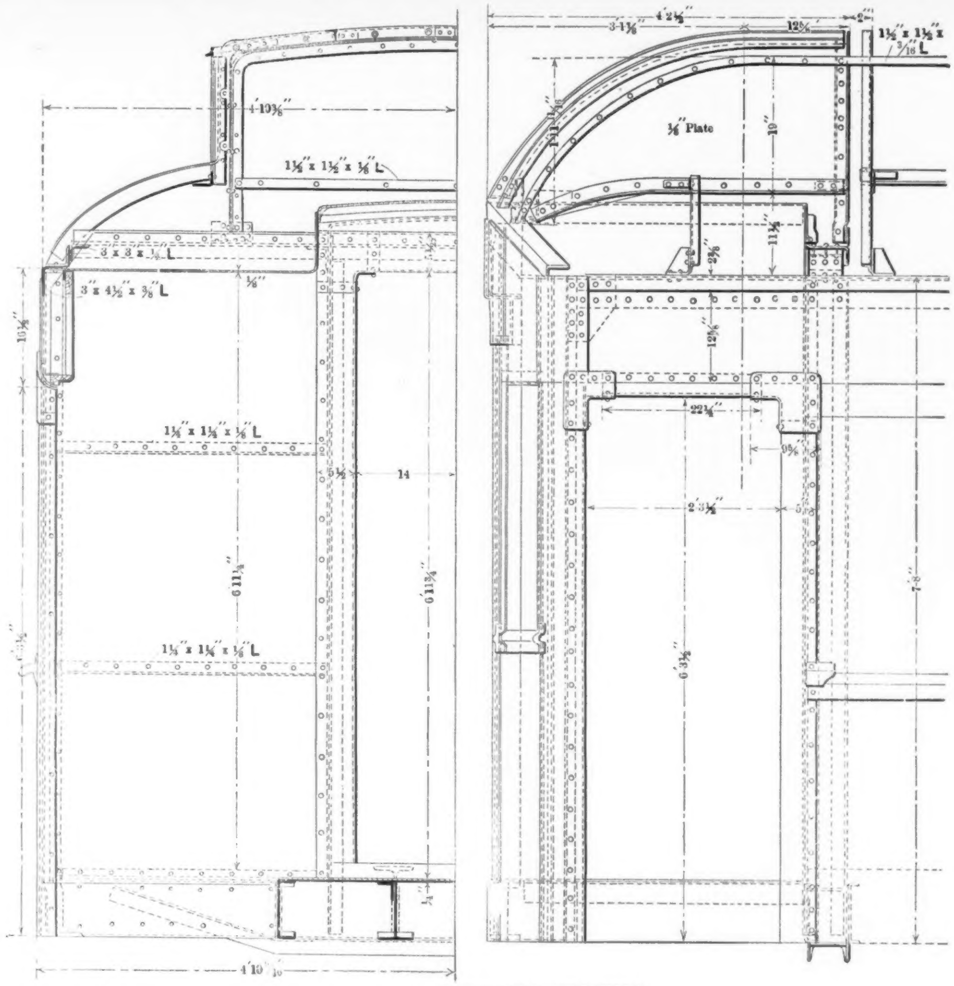
The bolsters are also formed of pressed steel fillers or web plates, there being a pair between the side sill and the platform intermediate sill, another between that sill and the center sills and a cast iron spacing piece between and below the center sills. A heavy bottom cover plate 1 x 10 ins. is carried from side to side of the car and securely riveted to the side sills and filling pieces. The top cover plate, ¾ x 10 ins. in size, is formed in three sections with a lapped splice, the center section extending through the web of the center sills. This construction is so designed for the purpose of making it possible to remove these cover plates if necessary without disturbing the side sheathing. The two bolsters are about 5 ft. apart, and, as above mentioned, transfer their load to the center sills at this point. For a distance of 3 ft. on the bottom of these sills, between the bolsters, there is a heavy cover plate, to which the center plate is fastened, and sills are further reinforced by a top plate of channel shape riveted to the webs of both sills.



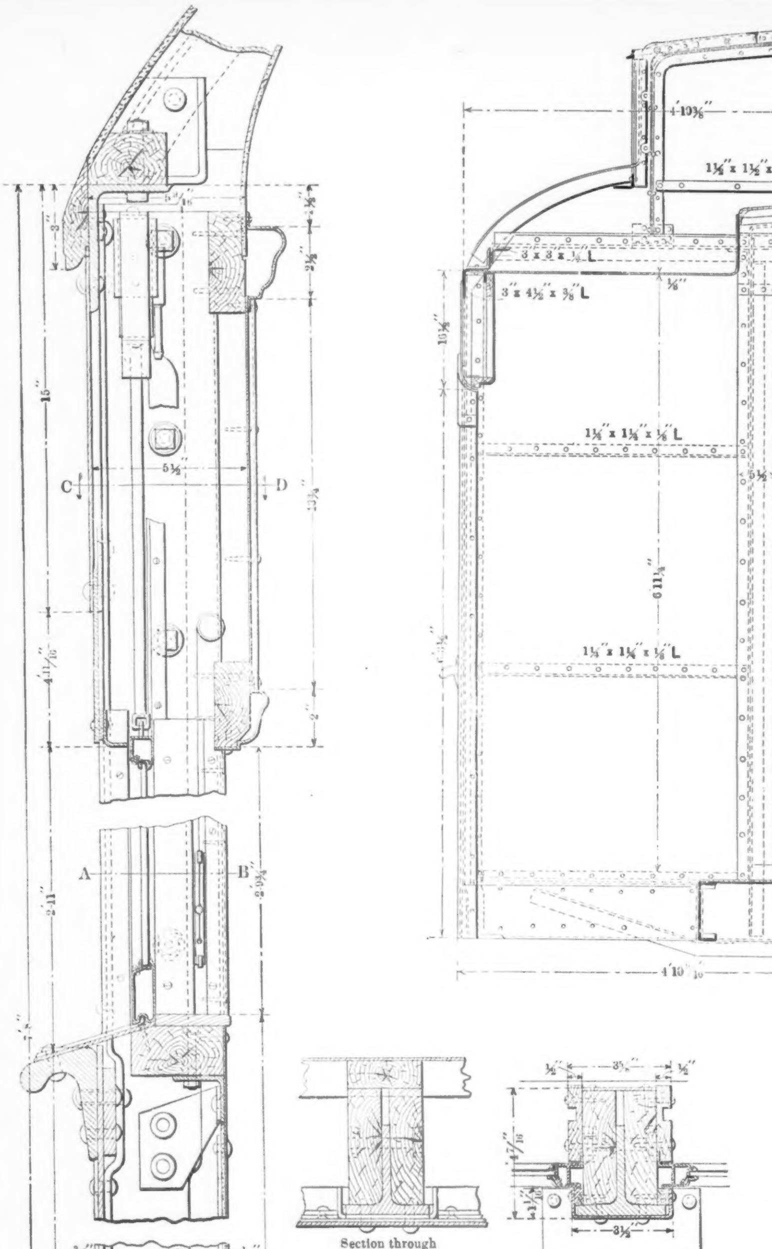
ROOF FRAMING—LONG ISLAND STEEL COACH.



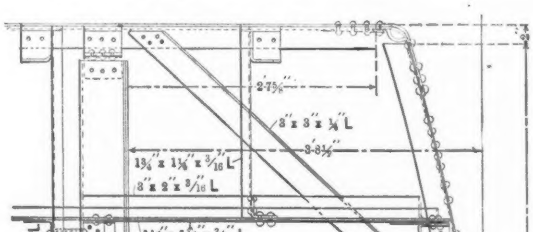
SIDE FRAMING—LONG ISLAND STEEL COACH.



VESTIBULE FRAMING.



DETAILS OF SIDE FRAMING.



PLAN OF PLATFORM AND VESTIBULE ROOF FRAMING.

The end sills also consist of double flanged plates between the longitudinal sills, and include a channel which passes continuous below the center and platform sills and is turned up at either end and securely riveted to the flanged plates.

The draft gear, as previously mentioned, is of the Westinghouse friction type, and because of the height of the center sills narrow draft sills were necessary, these being formed of pressed steel shapes and securely riveted to the bottom of the center sills, extending back beyond the draft gear and having a cover plate so arranged as to assist in transferring the buffing stress over some distance on the center sill. The draft gear cheek plates connect partially to the center sills and partially to these draft sills, the center line of the draft gear being nearly on a line with the lower edge of the center sill. The buffer is of the Gould friction type, and is located a short distance above the center line of the center sills, so that in case of a heavy buffing stress it will be transferred to very nearly the center line of the sills.

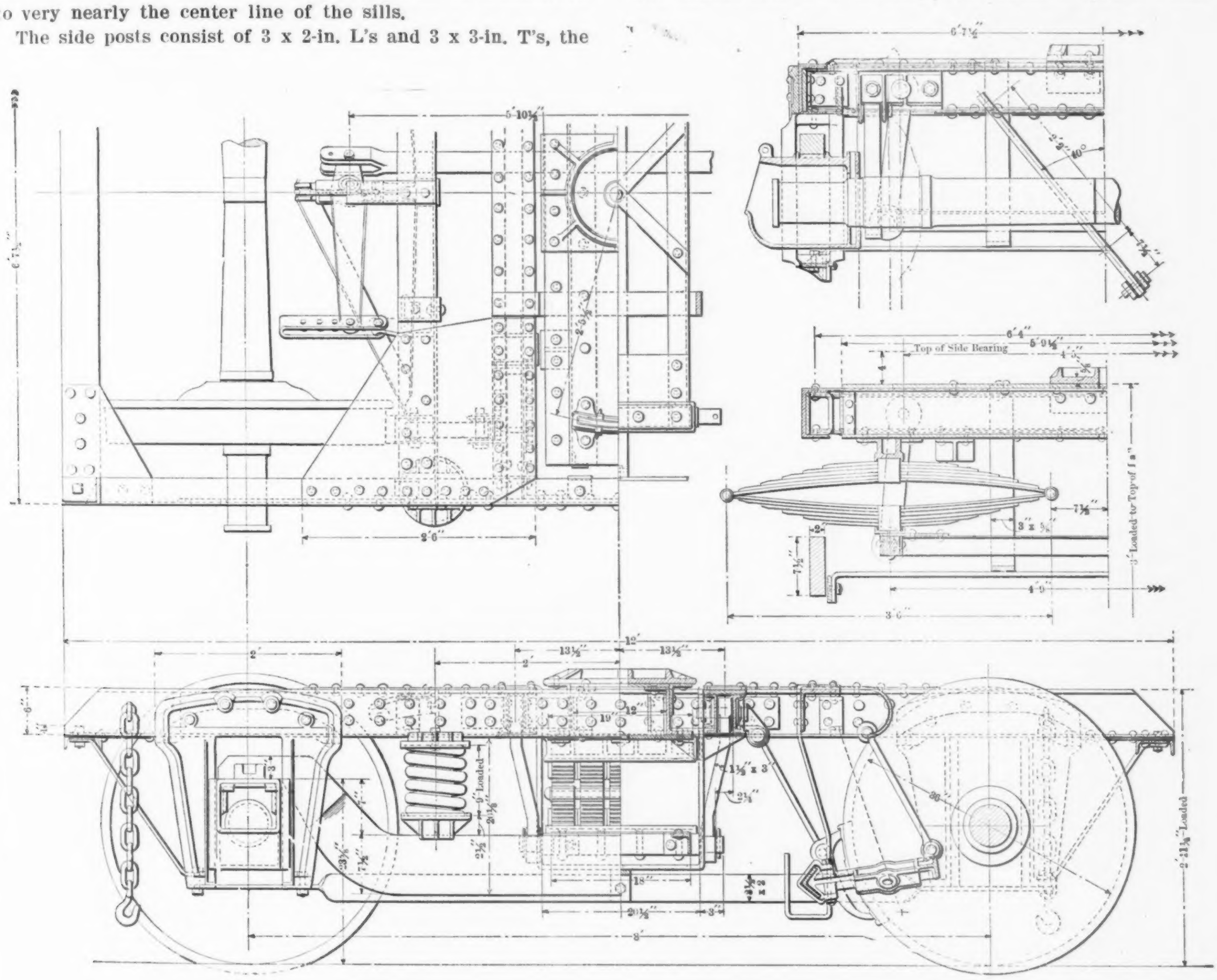
The side posts consist of 3 x 2-in. L's and 3 x 3-in. T's, the latter forming the single posts and two of the former, spaced at various distances apart, forming the double posts. These are offset at the bottom and belt rail, as previously mentioned. At the top they connect to a side plate angle of 4½ x 3-in. section, which extends continuous from end to end of the car.

The carlines, consisting of light angles in one piece from side plate to side plate, are bent to the proper contour and connected to the side plate by light pressed connections. There is a carline at the junction of each side post. The bracing and stiffening of the roof construction is clearly shown in one of the illustrations. Special attention, however, might be drawn to the fact that there is a vertical ⅛-in. steel plate forming the side of the clerestory in the vestibule. This plate, with its angle iron connections, acts as a cantilever for supporting the weight of the vestibule, and also is of great value as a stiffener to prevent the collapse or crushing of the vestibule in collisions.

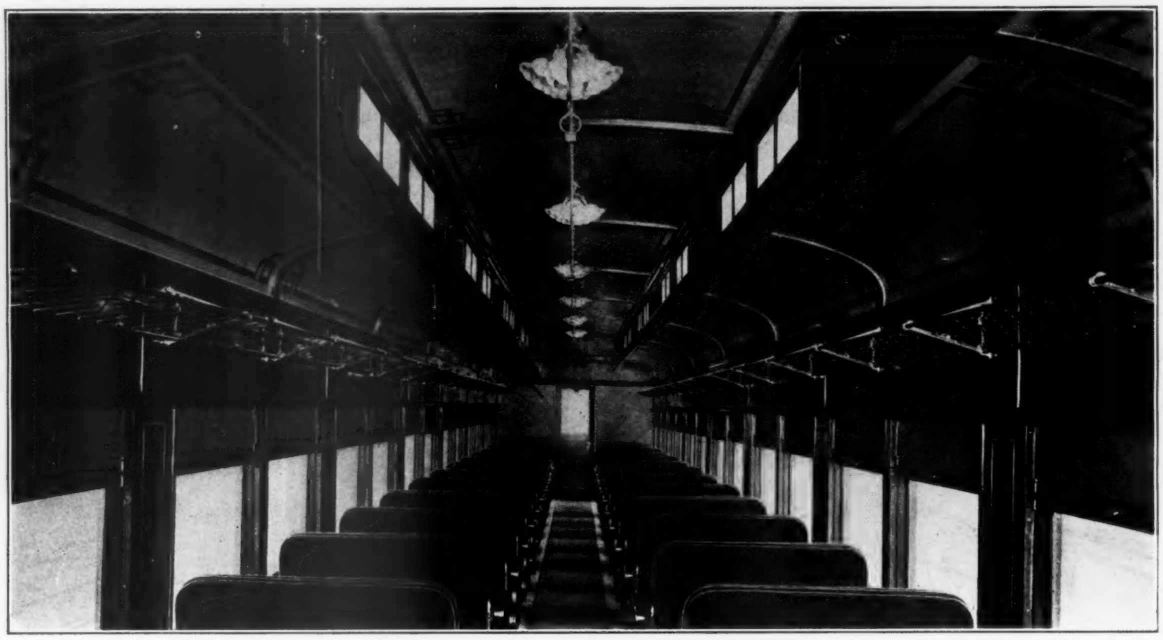
The interior finish is of steel, with the exception of the head lining, which is of a material known as "Durite." The pressed steel mouldings, battens, etc., are connected to the steel framing in many cases by means of wooden fillers, as is shown in the enlarged section through the side of the car. However, it might be mentioned that some of the sections shown in this illustration as being of wood were actually constructed of pressed or drawn steel. In fact, there is absolutely no wood used that is not encased in metal. The window sashes and the window sills are both of steel. The interior is painted in an excellent imitation of mahogany, and to all appearances is finished in wood, giving it the same pleasing appearance that is found in modern passenger cars.

The outside roof is of "Durite," over which is spread a canvas cover, the corners, hoods and hips having copper flashings. The construction in this respect is that usually found on wooden cars. The seats have a steel frame and plush cushions and backs, being furnished by Hale & Kilburn, and conforming to the standards of the Pennsylvania Railroad. The luggage racks are continuous.

The specialties used in this car outside of those already mentioned consist of the Gold car heating system; Pantasote curtains with Forsythe fixtures; Dahlstrom all-steel doors; Symington journal boxes; Baltimore Railway Specialty Company's side bearings; Schoen rolled steel wheels; Adams & Westlake hardware; Stanwood step treads; Westinghouse quick action brakes and air signals; Columbia lock nuts on all bolts throughout the whole car. The Universal Electric



TRUCK FOR LONG ISLAND STEEL PASSENGER COACH.



INTERIOR OF LONG ISLAND STEEL PASSENGER COACH.

Storage Battery Company's lighting system is used, which consists of 32 cells, with a capacity of 600 ampere hours, and is capable of lighting all of the lights in the car for a continuous period of 30 hours without recharging.

The trucks, as can be seen in the illustration, follow the general lines of a standard equalized passenger truck, with a wheel base of 8 ft. They are steel throughout, and of a very open, simple construction.

The general dimensions and weights of this car are as follows:

Length over buffers	67 ft. 4¼ ins.
Length over body	58 ft. 5¾ ins.
Width over sheathing	9 ft. 8⅝ ins.
Width over all	10 ft. 2⅛ ins.
Height rail to top of roof	14 ft. 0¼ in.
Height rail to bottom of side sills	3 ft. 5½ ins.
Truck centers	45 ft. 3 ins.
Height rail to top of platform	4 ft. 1¾ ins.
Clear width of aisle	25⅝ ins.
Seating capacity	72 persons
Weight of body	66,800 lbs.
Weight of trucks	22,000 lbs.
Storage batteries, including boxes, hangers, etc	5,700 lbs.
Total weight in running order	94,500 lbs.

RAILROADING FROM A BUSINESS POINT OF VIEW.

Railroading consists essentially in the manufacture and the sale of transportation, and it is obvious that it should be made as cheaply as possible and sold for as good a price as the market will afford. To accomplish either of these purposes involves the same knowledge of facts that must be possessed in the manufacture of any other commodity. I believe that it is true that in no business of equal magnitude are books kept with so little reference to the collection of useful facts. The accounts that are kept are, in the most part, of very little value, because very ordinary investigations may prove them to be incorrect in detail, and even when one essays to obtain a statement of the cost of repairing any particular engine or engines, or any of the many facilities which are employed by any great railroad, the result will be disheartening in the extreme. Nevertheless, every railroad in the country goes on piling up figures which are meaningless, and which are not and cannot be used for the only purpose for which they should be made, viz., to make it possible to determine with approximate exactitude the relation between the cost and the selling price.

To my mind, the practice pursued by most roads in an endeavor to secure minute supervision of its affairs is short-sighted in the extreme and results in the perfunctory performance of many duties by officials receiving high salaries, who could be much more profitably employed in looking after other matters. Cases repeatedly come to my attention in which requisitions are made for certain articles which are indispensable and in current use. These requisitions possibly require the signature of at least a half dozen different officials, and it is quite probable that a month may elapse from the time the requisition is made until it receives all the approvals which are deemed necessary in order to enable the purchasing agent or storekeeper to furnish it. Of course, some requisitions are disallowed, and properly so; but all that is saved through this procedure is wasted many times over by the delays which result in securing the things that are really necessary.

My own idea in regard to matters of this kind is that there should be some official connected with the auditing department and allied with the purchasing and store departments, who will have authority to approve requisitions which should come to him usually with not more than two signatures; first, that of the man who originates the request; and second, that of his immediate department superior. If error is made, or if a man is extravagant, the fact will be very soon ascertained and the proper corrective applied. As hereinbefore stated, many records are made which are absolutely valueless. A great many of them were legitimate enough when they were inaugurated, but the necessity for them has passed, and they are still kept up as a matter of form.—*Mr. J. W. Kendrick, second vice-president of the Santa Fe, before the New York Railroad Club.*

Brake Shoes on the Subway.—Twenty tons of brake shoes per month are stated to be used up in the New York Subway. The brakes are applied, it is said, for nearly one-quarter of the total time of running upon the local train runs and for about one-eighth of the total running time of the express trains.—*Eng. Record.*

Superheated Steam in Locomotive Service.—The Carnegie Institution of Washington, D. C., has made a grant of $3,000 a year, for a period of four years, to Dean W. F. M. Goss, of Purdue University, Lafayette, Ind., for the purpose of determining the value of superheated steam in locomotive service; first, in connection with single expansion engines; and second, in connection with compound engines. This is the second grant which the Institution has made to Dean Goss. While given to him personally, its effect will be to stimulate and to make more effective the work of the Purdue Locomotive Laboratory. Funds thus received will be employed in supplementing the resources of the laboratory as derived from all other sources.

RAILROAD SHOP ORGANIZATION.

BY C. J. MORRISON.

A visit to a number of the largest railroad repair shops reveals the fact that in each shop there is a state of more or less dissatisfaction with the amount of work done and its cost. Each shop is endeavoring to improve its output, both in quantity and cost, and is diligently inquiring what the other shops are doing and how they are doing it. A great many methods for procuring the desired results are tried. One shop learns of the way certain work is handled in another shop and adopts the method bodily only to find it a failure when transplanted.

A very interesting comparison of the different methods of handling work is obtained in a large repair shop, which we shall designate as No. 1, having one general machine shop and three separate erecting shops under different foremen. Two of the erecting shops are small, comparatively dark and crowded, while the third is light, thoroughly modern in every respect, and has more floor space per engine than any other railroad repair shop in the country. The two older shops have only fair crane facilities, while the new shop has not only three large cranes, capable of lifting the engines, but four jib cranes, which run over the engines and handle light material. All three shops are longitudinal. The road has a large number of engines of one class, so that the work in the three shops is practically the same. The new shop uses the highly specialized method of a gang for every job. One gang does all the steam chest work, another all frame work, another all cylinder work, and so on. One of the older shops uses practically the same method, but does not specialize to quite as fine a point as the new shop. The other shop uses the method of having each gang take three to five engines and carry through all the work, from stripping to firing up. The same piecework prices prevail in all three shops, and all work is delivered from the machine shop fit up ready to go on the engines. Strange as it may seem, the output from each shop is exactly the same when reduced to a man hour basis. In other words, the efficiency of the man is not increased by improved conditions and specialized methods.

Another railroad in the same district has a shop (No. 2) in an old, dark building, which is so badly out of repair that numerous props are required to keep it from falling down. This is a transverse shop, with no cranes, and so badly designed that often one engine has to be pulled outside before another can be wheeled. Wheeling and unwheeling are done by a drop table, which can handle only one pair of wheels at a time. Wheels and boilers must be pulled out into the yard and switched to the wheel shop and boiler shop, respectively. In fact, the conditions are generally adverse, and the only redeeming feature is the fact that the shop is well provided with modern machines and tools. The piecework system is used, and the prices are somewhat lower than at Shop No. 1. In the erecting shop there are only three gangs; one does the stripping, one all the work below the running boards, and the third all the work above the running boards. All fitting up is done in the machine shop. The engines are about the same weight and general dimensions as on the first road, yet the output of this shop on the man hour basis is far greater than at Shop No. 1. Again it appears as though the conditions do not affect the efficiency of the men.

A third shop (No. 3) in a different section of the country, and using entirely different methods, has practically the same man hour output as Shop No. 2. This last shop is operated on the individual effort method; has a splendid shop building, housing boiler, erecting and machine shop under one roof; poor crane facilities, excellent light, fair machine equipment and ample erecting space. The specialized gang system is used, but the gangs both fit up and erect. For example: The guide and piston gang not only does all the bench work on guides, pistons, cylinder heads, casings and crossheads, but puts them on the engine. Here are two shops, with entirely different methods and conditions, yet with the same efficiency on the man hour basis.

As it is scarcely just to compare piecework with daywork shops, let us consider two daywork shops within ten miles of each other, and handling almost the same class of engine. One has splendid buildings and practically every modern improvement, while the other has old, out-of-date buildings, no cranes, and no modern improvements of any description except that there is a good equipment of machine tools. The second shop gets out 50 per cent. more work on the man hour basis than the first one.

These facts are sufficient to cause one to stop and think. What causes these differences? What influences the efficiency of the men? Not only do some shops get a low efficiency, but the surcharges are enormous, due to the expensive equipment. If the shop methods and equipment do not affect the efficiency, there is only one other source to look to—the organization.

At Shop No. 1 there is divided responsibility, the shop being under the management of two men, neither one of which is in complete charge of any one department or responsible for the output. Each shop has a foreman, who spends most of his time in the office going over time cards, piecework rates and other clerical work. The gang leaders are paid by the day, and earn considerably less than the men under them. Naturally, they have no incentive to push the men, and are jealous of their earnings. As a result the efficiency is low.

At Shop No. 2 one man is directly responsible for the output, and is directly in charge of the work. Under this man are foremen, gang leaders, and an assistant who, in a commercial establishment, would be known as a "pusher." It is his duty to push and see that every man and every machine is going at full capacity. The foremen have nothing to do with piecework rates or timekeeping, but give all their energy to getting out work. They receive a monthly salary which is large enough to keep them from being jealous of the pieceworkers. The gang leaders work piecework and, as their earnings increase with the men's, have every incentive to hustle and push the men.

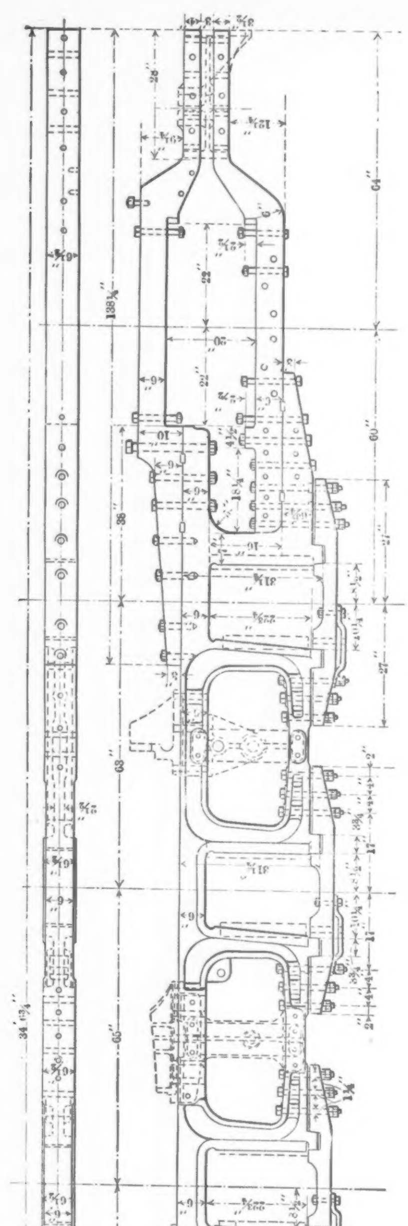
At Shop No. 3 one man is directly responsible for the output. An inspector relieves him of the responsibility of deciding what work shall be done and looking after material. The foreman and gang leaders have no offices and do practically no clerical work. All work is done under the individual effort method, and the foreman's or gang leader's bonus increases directly as the men's. Moreover, he receives an additional bonus for getting out work ahead of the schedule time. The result is high efficiency of the men.

In the first of the daywork shops the chief duties of the foremen seem to be to order material and to assign work to the men. The idea of timing an operation or of trying to push the work seems to have never entered their heads. The men practically work as they please, and an extremely low efficiency results.

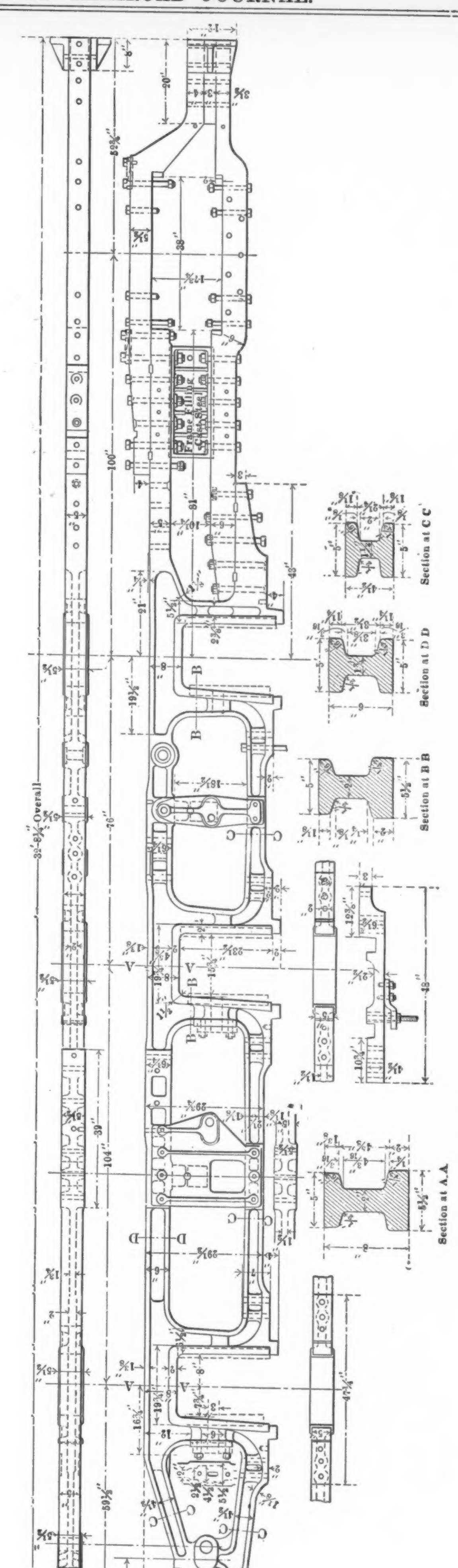
At the other daywork shop an accurate record is kept of each day's work, and if a foreman has fallen below his allotment he is immediately notified. He is also notified if the price is higher than the price on the same article at any former time. This causes the foremen to not only push the work all they possibly can, but also to hold down the price. Even in a daywork shop this can be done in a number of ways.

It would appear that the most important item about a shop is its organization. Organization costs less than equipment and seems to produce better results. Not that good foremen can be gotten for less than mechanics, for they never can; in fact, in order to obtain a good organization, what may appear to be high wages may have to be paid. The ideal condition for producing large output at low cost, therefore, seems to be a cheap building, no expensive cranes, good machine equipment, and an organization that works as a unit and is always on its toes.

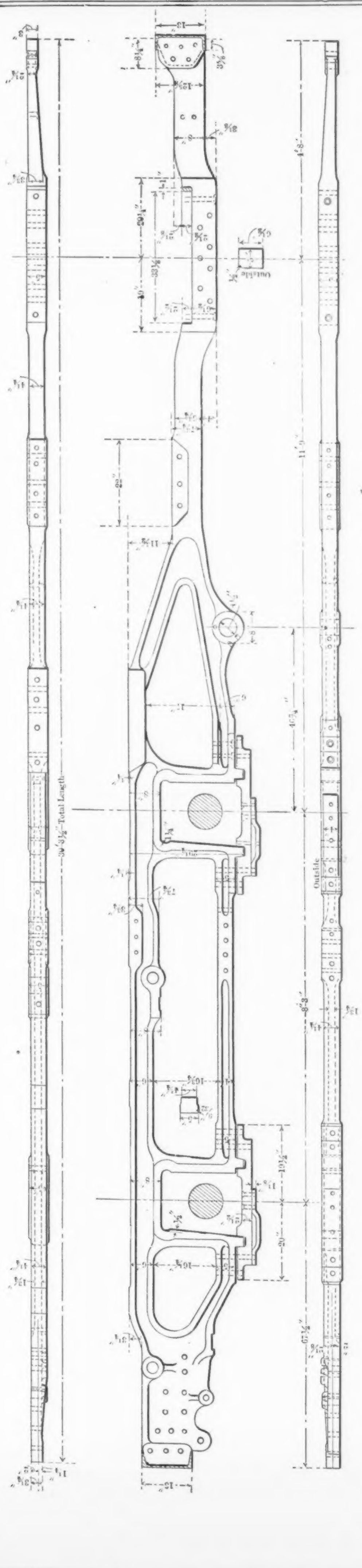
The man in charge that is missed when temporarily absent is a bad organizer.—*Mr. D. T. Taylor.*



CAST STEEL FRAME FOR CONSOLIDATION LOCOMOTIVE—DELAWARE AND HUDSON COMPANY.



CAST STEEL FRAME FOR TEN-WHEEL LOCOMOTIVE—DELAWARE AND HUDSON COMPANY.



CAST STEEL FRAME FOR AMERICAN TYPE LOCOMOTIVE—CENTRAL RAILROAD OF NEW JERSEY.

CAST STEEL LOCOMOTIVE FRAMES.

About five years ago Mr. J. R. Slack, then superintendent of motive power, and Mr. G. S. Edmonds, then mechanical engineer of the Delaware & Hudson Company, took up the subject of frame failures in an energetic manner and made a series of records and studies of all the failures on the road, which resulted in the designing and applying of several cast steel locomotive frames having an I instead of a rectangular section.

The service of these frames was so satisfactory that the design has been continued by the present superintendent of motive power, Mr. J. H. Manning, being improved from time to time, and at present it is very extensively used on that road on all types of engines.

The illustrations show frames used on both the 10-wheel and consolidation locomotives of the D. & H. Co., and also one of similar type that is used on the Central Railroad of New Jersey, being applied to a heavy American type locomotive recently built by the American Locomotive Company. The 10-wheel locomotive on which the frame shown has been applied was illustrated in the AMERICAN ENGINEER AND RAILROAD JOURNAL, February, 1906, page 65. It weighs 173,000 lbs. total, with 130,000 lbs. on drivers, and has 21 x 26-in. cylinders and a tractive effort of 31,000 lbs. The consolidation locomotive was illustrated in January, 1907, page 22, and weighs 246,500 lbs. total, of which 217,500 lbs. is on drivers. The Central Railroad of New Jersey locomotive has 19 x 26-in. cylinders, weighs 108,000 lbs. on drivers and 158,000 total, and has a tractive effort of 23,120 lbs. with 69-in. wheels.

This design of frame was first illustrated by an article in the AMERICAN ENGINEER AND RAILROAD JOURNAL in May, 1901, page 149, which contained illustrations presented for criticism by Mr. Van Ness Delamater, then a student at Cornell University. In September, 1901, page 287, Mr. G. S. Edmonds presented a communication treating the subject from a theoretical standpoint, and showed that for the same amount of metal and the same width of frame the I section was about four times as strong in the horizontal plane, but was a little over half as strong in the vertical plane. In the issue of November, 1901, page 356, was illustrated the first frame of this design used by the Delaware & Hudson Company, which was applied to an American type engine. In October, 1903, page 365, extracts from a paper by Mr. Edmonds, on "A Rational Method of Designing Locomotive Frames," presented before the Pacific Coast Railway Club, were published, in which the subject is summed up as follows:

"Analyzing, we know that:

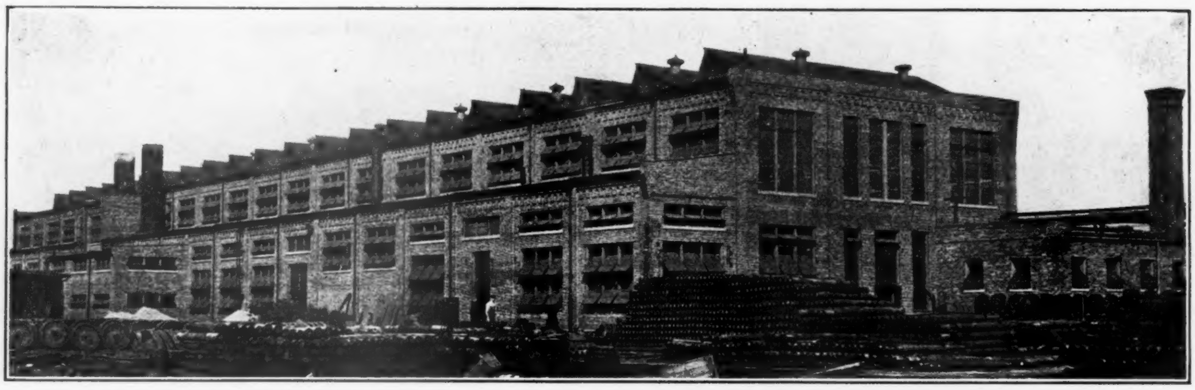
"1. A web section gives us higher moments of inertia per unit weight than any other.

"2. A frame casting is such that the use of coring must be eliminated, else first cost will be excessive, with possibilities of shifted cores.

"3. The second condition reduces the number of available web sections to channel and I sections. When we consider the problem of molding, with shrinkage effects, the latter seems decidedly the more desirable of the two. The comparative thinness of the I casting allows of a ready and careful examination by the inspector, whereas with the rectangular section, oftentimes the outer surface covers a multitude of sins, discovered only when failure of part discloses interior honeycombing. Hence, while of higher factor of safety if sound, the uncertainty of the material, for above reason, favors the I section."

The continuance of the design on the D. & H., especially its use on the very heavy and powerful consolidation locomotives, would indicate that several years of service had proved the truth of the above conclusions.

While it is not as difficult to get sound steel castings to-day as it was a few years ago, and there is probably no great saving in weight with this design, nevertheless, the opportunity to place the metal where it is most needed and in a position to



FOUNDRY, SOUTH LOUISVILLE—LOUISVILLE & NASHVILLE RAILROAD.

give the greatest service, as well as to eliminate superfluous metal where it is not needed, are sufficient to make these frames worthy of careful consideration.

SOUTH LOUISVILLE SHOPS.*

LOUISVILLE & NASHVILLE RAILROAD.

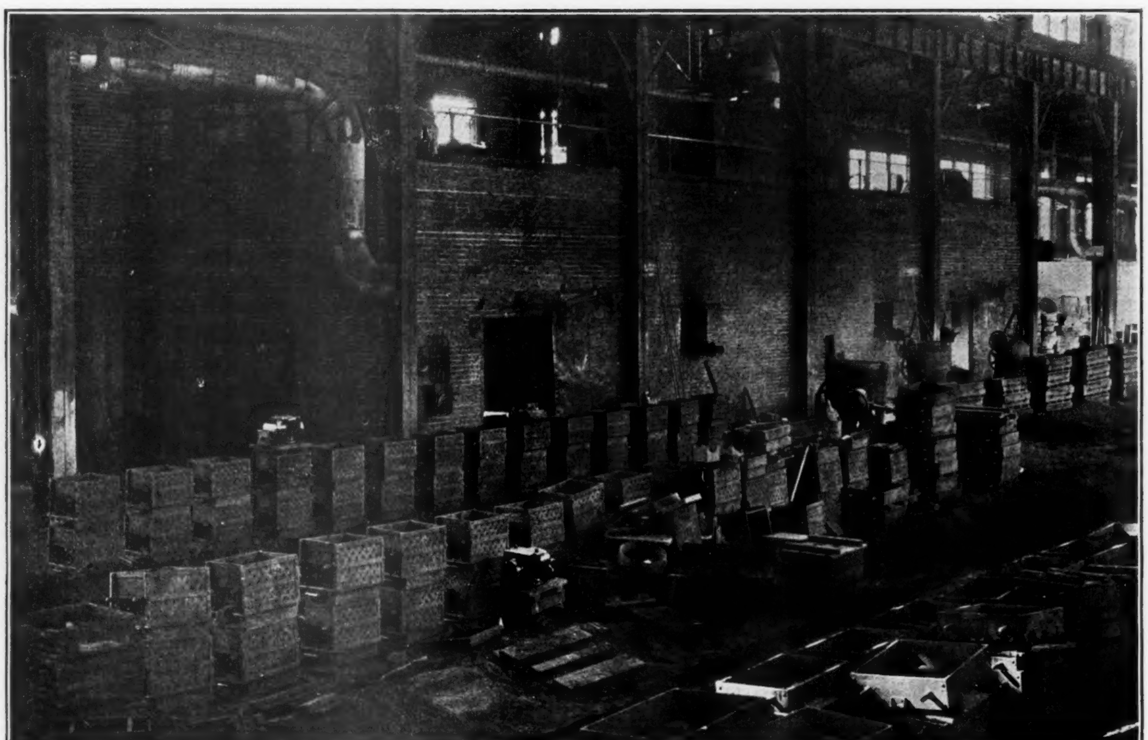
IV.

FOUNDRY AND PATTERN SHOP AND STORAGE BUILDING.

Grey Iron Foundry.—In the first article of this series, page 209, June, 1906, mention was made of the fact that the shops are arranged about an L-shaped system of transportation, consisting of a high-speed transfer table and an overhead traveling crane; also of the fact that all lumber enters at the south end of the plant and all metal at the north end, both progressing steadily toward the point where they will be placed on the finished car or locomotive, or where they will be finished ready for shipment to outside points, when they are either transferred to the storehouse or loaded for shipment at the most convenient place nearest to the point where they are finished.

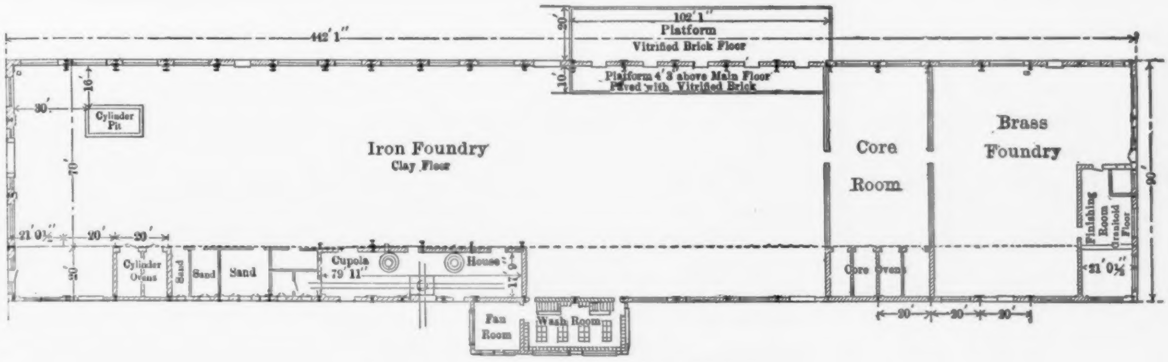
In keeping with the scheme of having the raw material enter at the ends of the plant and travel steadily toward its objective point, without doubling on its tracks, the foundry is placed at the extreme north end of the plant. The raw material for the foundry is stored at the west side of the building, while the finished material comes out on the shipping platform at the east side, and from there is either transferred by the traveling crane and the transfer table, if it is to be used in the plant, or if intended for shipment to outside points is loaded directly into the cars. Brass castings for shipment to other points, or if not immediately required for use in the plant, are transferred to the storehouse by the traveling crane and the transfer table. In order that the journal boxes may be transferred from the foundry direct to the truck erecting department, or be shipped direct from the foundry, a drill press is placed in the finishing end of the foundry, and the bolt holes are reamed out. The traveling crane, which is 1,000 ft. long and extends to the transfer table, passes over the foundry shipping platform and ends near the middle of the building, as shown on the general plan, page 208, June, 1906.

The building is a steel frame brick structure, about 90 by 440 ft., the main portion being formed of a single span, 70 ft. wide, with an addition 20 ft. wide opening into the main portion and extending along the western side. The roof of the main portion is of the saw tooth type, the sides containing the glass facing north. A composition roofing is used on the



INTERIOR OF GREY IRON FOUNDRY—SOUTH LOUISVILLE.

* The previous articles of this series were: General Plan and Operation, page 209, June, 1906. Car Department, page 379, October, 1906. Power House, page 419, November, 1906.



PLAN OF FOUNDRIES—SOUTH LOUISVILLE.

main part, while the roof of the addition is of Book tile covered with composition roofing.

The building is divided by two brick walls, 3 ft. 6 ins. high, into three parts, the top of these walls being covered with iron coping and having a wire partition extending 6 ft. 6 ins. above them. The grey iron foundry is about 320 ft. long, the core room 40 ft., and the brass foundry about 80 ft.

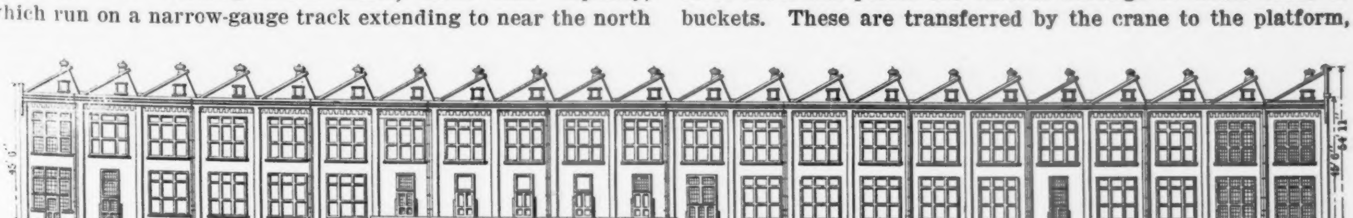
Two 54-in. 80,000 lbs. capacity cupolas, built by the Whiting Foundry Company, are placed at about the middle of the west side of the iron foundry, as shown on the plan view. At present about 60 tons of grey iron castings are being turned out per day. Small cars containing the charges are brought in from the stock yard over a system of narrow-gauge tracks. These cars are weighed on the scale at the entrance to the cupola room, and are then run on an electric elevator, just back of and between the two cupolas, and are elevated to the charging floor. Tracks extend from the elevator to each of the cupolas, and a turn-table on the elevator makes it possible to run the car to either one of them. The cupolas are operated by two No. 8 motor-driven Sturtevant blast fans, which are suspended from the charging room floor. Spouts project from the cupolas through the brick wall of the cupola room and discharge into Whiting truck ladles, three tons' capacity, which run on a narrow-gauge track extending to near the north end of the building. The ladles are poured by means of the Niles 20-ton traveling crane, which has a span of 67 ft. 2 ins., and extends the entire length of the building.

The cores for the grey iron castings, except for the very large ones, and for the larger brass castings are made in the core room between the grey iron and brass foundries, and baked in the four large ovens. These are heated by open fires placed in one end of the oven. The core racks are placed on trucks, which are run into the oven over narrow-gauge tracks. These racks are arranged in sections, so that when the cores have been baked the different sections may be lifted off by the traveling crane and be transferred to the most convenient points on the moulding floor. The cores for the larger castings are made near the north end of the building and baked in ovens at that point.

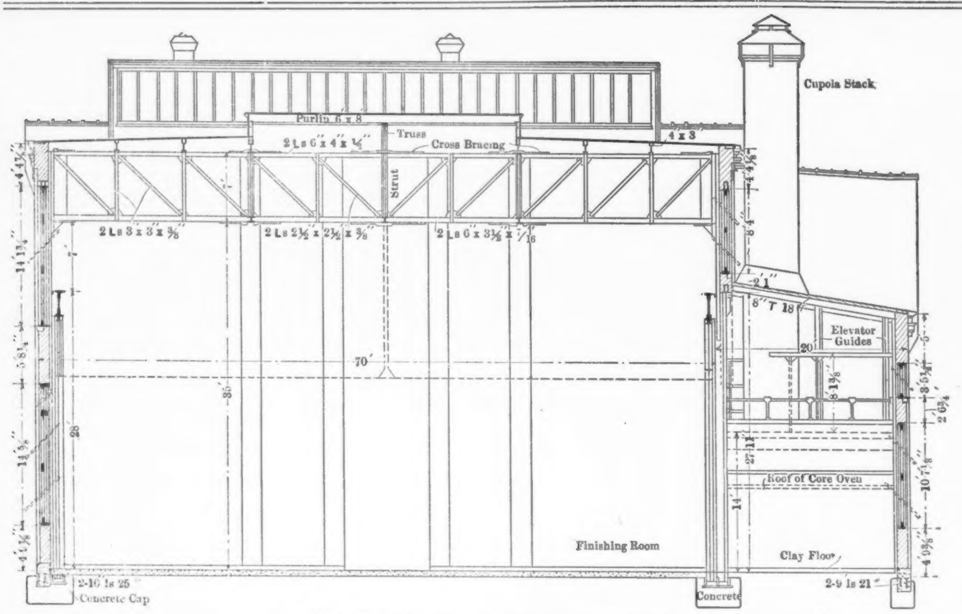
The tumblers, cleaning benches, emery wheels and the drill for reaming holes in journal boxes are placed at the south end of the iron foundry. The smaller castings are made at this end of the foundry, while the larger ones are made at the other end, a special pit being provided for moulding and casting cylinders.

After pouring off the moulds are opened up, and the night force sorts and places the various castings in metal boxes or buckets. These are transferred by the crane to the platform,

END ELEVATION OF FOUNDRY BUILDING.



SIDE ELEVATION OF FOUNDRY BUILDING.



CROSS-SECTION OF FOUNDRY BUILDING.

inside the foundry, and emptied into six tumblers. After they have been cleaned the tumblers are opened up and the castings are dropped through chutes to the main floor. The fins and sprues are then ground off on emery wheels, and the castings are given such hand cleaning as may be found necessary, and are then thrown into buckets and transferred by the crane to the shipping platform. The flasks are stored just outside of the north end of the building.

The building is heated by the Sturtevant hot air system; the fan room is at the west side of the building. Several of the hot air pipes are shown in one of the accompanying photographs. A two-story addition, adjacent to the fan room, is used for wash and locker rooms, expanded metal lockers being used.

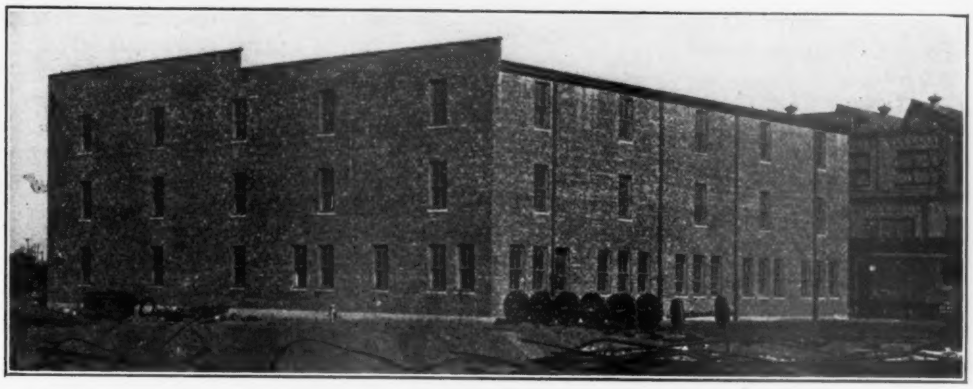
Brass Foundry.—This foundry has an output of five or six tons per day. It contains a double Rockwell rotary melting furnace, a Schwartz rotary and a Porteous portable melting furnace. The small cores for this department are baked in an Eli Millets' patent oven. The castings are cleaned in two 20 x 32-in. tumblers, and from these are emptied directly into the finishing room, which has a granitoid floor, and is equipped with an F. B. Schuster sprue cutter. The car brasses, after being cleaned, are bored on a Niles lathe made specially for this purpose. This lathe finishes eight brasses at a time, and with two operators can easily finish 800 brasses per day. The brasses, after being lined with soft metal, are placed in iron buckets and transferred by the overhead crane to the doorway, and are then pushed out and carried by the traveling crane to the car department or to the storehouse, as may be desired. The finishing room is equipped with a magnetic separator made by the Dings Electro-Magnetic Separator Company, and also with the necessary equipment for casting packing rings and a 14-in. lathe for turning them.

Pattern Building.—The pattern building is about 100 ft. square and three stories high. Except for the pattern shop floor and office, on the ground floor, it is practically fireproof. The window frames and sash, as well as the doors, are covered with galvanized iron. The building is a steel frame brick structure, and the floors, except for about 20 per cent. of the first floor. in the pattern shop, are of granitoid. In addition to the stairways there is an 8 x 10-ft. electric elevator from the first to the third floor. A narrow-gauge track extends from the foundry to this elevator. A room is also partitioned off on the first floor for the laboratory of the engineer of tests.

In the pattern shop the benches are placed along the three sides of the room in front of the windows; the machine tools are placed in the middle of the room and along the partition wall. The windows are of wire glass. Reference to the drawings will show that the number of windows in the part of the building devoted to the pattern shop is much greater proportionately than for other parts of the building. One end of the shop is devoted to the necessary apparatus for making metal patterns. The machine tools are arranged in one group and driven by a 14-h.p. motor. The list of tools in this shop is as follows:

Pattern makers' gap lathe, 25 to 50 ins. swing, 10 ft. bed—Putnam Machine Company.
16 in. x 8 ft. wood lathe.
12 in. x 4 ft. metal lathe—Sellers.
20 in. Oliver hand planer and jointer—American Machinery Company.
24 in. hand surface planer—J. A. Fay & Co.
Oliver universal saw bench—American Wood Working Machinery Company.
Band saw No. 0—Fay & Egan Company.

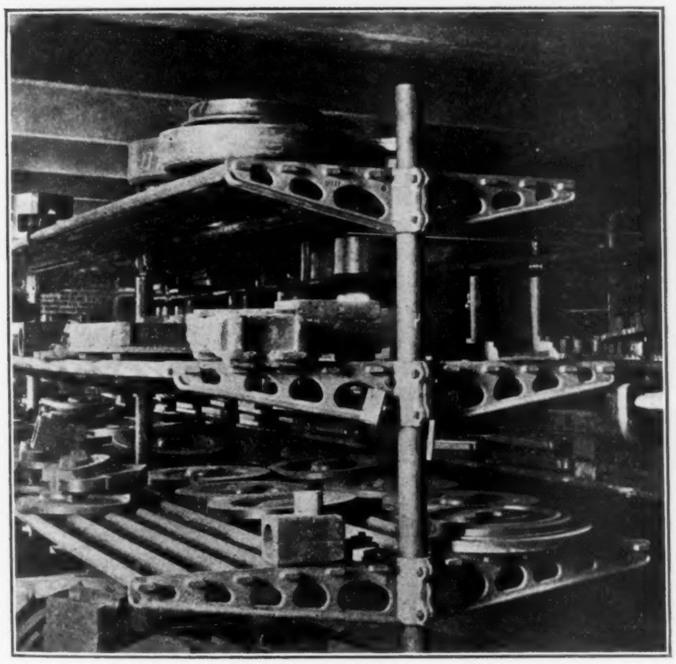
PART LONGITUDINAL SECTION OF FOUNDRY BUILDING.



PATTERN SHOP AND STORAGE BUILDING.

20 in. drill—W. F. & J. Barnes, No. 1.
Fox trimmer—Grand Rapids Machinery Company.
18 in. crank shaper—American.
Grindstone.

The heavy patterns are stored on the first floor. A very neat and cheap rack is used for storing the lighter patterns on the second and third floors. These racks are made of several castings clamped to a piece of heavy pipe, as shown in one of the illustrations. The base casting, which unfortunately is not



PATTERN STORAGE RACK.

shown, is similar to the other castings, but turned upside down. The ends of old boiler flues are shaped to fit over the lugs on the castings, and the rack is tied together by several longitudinal rods. As scrapped flues are used, and the castings are of very simple design, the rack is inexpensive, and at the same time is especially well adapted for the purpose. For very small castings boards are laid over the flues.

Each floor of the building is equipped with fire hose and connections. Incandescent electric lights are used.

STEAM TURBINES.—So far steam turbines of the Parsons type have been manufactured to give a total of 870,000 h.p. Of this 200,000 h.p. came from American builders, and 350,000 h.p. from the original Parsons' Works in England.—*Machinery.*

PLANER OUTPUT.

The following interesting suggestion is reproduced from a catalog describing the high speed planers made by Bateman's Machine Tool Company, Ltd., Leeds, England:

The old practice of judging the comparative values of planing machines, by comparing their speeds on cut and return, has been found very misleading. This is because of the momentary stoppage of the table at each end of the stroke and the time lost before full speed is attained after reversal. In some machines these losses are very considerable and materially reduce the productiveness of the tool, and if such machines were sped up the loss on reversal would be enormously increased. The only accurate means of ascertaining the earning capacity of a planer is to take the cycle times as indicated below:

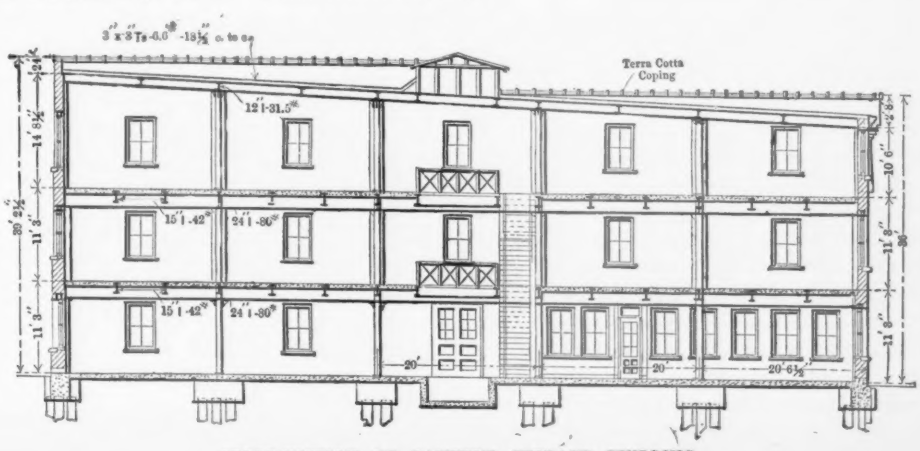
Time of cycle = time of 1 cut + time of 1 return.
L = length of stroke in feet.
T = time of N cycles in seconds.
N = number of cycles.

$$\text{Average (or earning) speed} = \frac{2L \times N \times 60}{T}$$

Thus a 42 in. x 14 ft. machine completes 10 cycles in 3 min. 56 secs. (236 secs.) when on a 14 ft. stroke. Therefore the

$$\text{average speed is } \frac{14 \times 2 \times 10 \times 60}{236} = 71 \text{ ft. per min.}$$

ACCURATE COST KEEPING.—The fiery test is competition, the prices at which the competitor gets the business. In railroading, whatever the condition of freight rates, the measure of success is production of transportation at least cost. When the mill cannot bid low enough to get the contract it must shut down. The railroad shops must keep going, thus the monthly or annual comparative statements seem to lose the biting sting of the selling price. Accurate and detailed cost-keeping is necessary to prevent the home manufacture of articles at a cost extravagant in comparison to the price for which the article can be bought outside.—*Paul R. Brooks, before the New York Railroad Club.*



CROSS-SECTION OF PATTERN STORAGE BUILDING.

THE RAILROAD Y. M. C. A.*

By Frank E. Haff.†

I have the greatest respect for the Young Men's Christian Association as an institution and the truest admiration for its work. I respect and admire it because it does things; because it has and can give an honest excuse for its existence; because it never stands solely upon its past record, but keeps up a continuous forward march; because it surrounds its members with a clear and healthful atmosphere; because it makes men healthy in body and soul, and because it teaches the real fatherhood of God and universal brotherhood of man.

In the operation of railroads many employes must necessarily spend considerable time away from their homes. Engineers, firemen, conductors and brakemen are frequently compelled to lay over from ten to twenty-four hours for the train which they may be scheduled to take back to their home point. Even when the character of the service permits them to return every night, there are of necessity many hours of leisure between runs at terminal points. Formerly these men were obliged by the utter absence of other accommodations to sleep in freight cabooses, coaches and undesirable boarding houses; and as for their hours of leisure, more often from necessity than choice, the most frequent place of resort was the saloon.

But nearly thirty-five years ago the Young Men's Christian Association began to take a special interest in railroad men. With that prescience for which it has become noted the world over, it recognized and grasped its opportunity. It organized a railroad department with the avowed purpose of ameliorating the intolerable conditions surrounding the lives of men engaged in the transportation service. As usual and because the cause was righteous, it succeeded. It awakened in both employer and employe a sense of the great danger to life and property lurking in the continued existence of those reprehensible conditions. The awakening was quickly followed by action, and in hundreds of instances the old order of things has become a mere memory. To-day tens of thousands of railroad men, on whose physical and moral condition depends the safety of millions of lives daily, find in the Railroad Young Men's Christian Association attractive and comfortable homes for their leisure hours. In these homes are provided a good restaurant, library, baths, bowling alleys, sleeping, rest, reading, smoking, game, and even in some cases emergency hospital rooms. But it is not alone the physical side that is looked after, for there is also provided every incentive for moral, mental and spiritual quickening. And what is the result? The placing of property of immense value and especially the lives of millions of people daily in charge of men who are sober and clear-headed; the sending out of train crews, clean, well-slept, alert; the gathering of young men during their leisure hours where physical exercise, recreation and Christian fellowship supplant the influence of the saloon, the gaming place, or worse. Is not the work justified by the result?

There are now 225 Railroad Y. M. C. A. organizations dotting the map of the North American continent, from Montreal to the City of Mexico, and from Portland, Me., to Los Angeles, Cal. Eighty-three thousand men are enrolled as members. During the past year ten thousand were added to the roster. While many of the buildings occupied by this army of railroad men are located at isolated and unattractive division or terminal points, their value exceeds $2,600,000. Sixteen new buildings are being constructed at a cost of more than half a million dollars. From this brief statistical statement may be gathered a fair idea of the present magnitude of the work.

Just a word with reference to the attitude of the railroad corporations toward this work. The president of one of the large Southern systems said in this connection a short time ago: "Since the introduction of Railroad Y. M. C. A. work on this line the loss due to wrecks caused by drunkenness on the part of employees has been reduced from nearly $1,000 per day to a little more than $100 per day." Is not that a splendid material result? But think of the moral uplift — of the great change in the character and lives of the men which made such a result possible.

One of the greatest tributes paid by a railroad official to the value of this work was by Mr. W. C. Brown, vice-president of the New York Central Lines, at the opening of a new Railroad Association building on the Lake Shore at Collinwood, Ohio, toward which his company has contributed nearly $40,000. Mr. Brown said: "I am glad to be with you to-night to participate in the dedication of this building to the service of God and to the comfort and convenience and betterment of the condition of railroad men. Eliminate from consideration if you will the religious and educational features entirely—inestimably important as they are — considering only the simple proposition of a clean, wholesome place to sleep and eat, free from the temptations which surround the young man employed on a railroad, under the most favorable circumstance, when thrown upon his own resources, and in my opinion no investment of a similar amount of money has ever paid or can ever pay so large a return as the money devoted to the construction and maintenance of these railroad departments of the Young Men's Christian Association. The railroad which annually draws thousands of young men from the villages and farms to fill up its ranks, depleted by age, accident and disease, owes something to this army of young men. They owe it to the men themselves; they owe it to the anxious, loving fathers and mothers back in the homes from whence these young men came; above all, they owe it to the public who daily place in the care and custody of these men their lives and property, to do everything within their power to make them the best, safest, most efficient men possible; and in doing this, in my opinion, no agency can be enlisted so adapted, so consecrated, so devoted to the work and so successful in the work as the railroad department of the Young Men's Christian Association."

In answer to a suggestion made to President Cassatt that part of the valuable room set aside in the new terminal station of the Pennsylvania Railroad in Manhattan be used for purposes other than Association work, he said, and with emphasis admitting of no further discussion, "That has all been settled." The inference is unmistakable that Mr. Cassatt, in common with many other presidents and lesser officials, considers the railroad department an essential feature of railroad equipment, and space or buildings worth thousands of dollars are well devoted to the work.

These instances attest in no uncertain tones the estimate which railroad officials place upon the value of the work the Association is doing for railroad men.

But if anything further were needed as an evidence of the attitude and appreciation of the railroad companies themselves, it could be found in the record of the large sums of money that every year are being appropriated for new buildings, equipment and maintenance, by boards of directors of railroads all over the country.

A further indorsement of the Railroad Association work comes from the Panama Canal Commission. With the approval of President Roosevelt and the Secretary of War it has been decided to turn over to the railroad department of the International Committee, for operation, the eight clubhouses which the Government is constructing in the Canal Zone for its employes, and carry the salaries of the secretaries on the Government payroll. During his present visit the President has promised to look into the work among the five thousand railroad men employed there in connection with the construction of the canal. Here we have official recognition of the value and efficiency of the work from the highest possible source and character.

But what of the attitude of the men themselves? Does not the immense army enrolled as members answer that question? But their estimate of its value can be no more eloquently at-

* From an address before the Bedford Branch, Brooklyn, N. Y.
† Secretary of the Long Island Railroad.

tested than by stating that they voluntarily contribute 65 per cent. of the cost of operation as against 40 per cent. ten years ago.

It may be suggested that this is a purely economic test; but as another has said far better than I can say it, "After all, the economic test is a fair one. Religion and education have a commercial value. Increase of knowledge, skill and morality always result in increase of earning capacity. Gifts come to the association from those who consider only that it is good business. The result attained satisfies the business sense and the subscriptions come pouring in. If a church or a religious order does not contribute to the economic welfare of a community it ought to go. If it is non-productive from a business standpoint it is because it is non-productive from a religious point of view. The development of conscience is a direct addition to wealth."

As a closing word let me say that splendid as have been the results achieved by the instigators of the movement and those who have carried on the work of the railroad department from its inception to the present time, so pregnant with glorious possibilities seems the future, that it is no idle prophecy to declare it to be as yet only in its infancy. God grant there may be no diminution of interest on the part of the employer or employee in the efforts being put forth by the railroad department of the Y. M. C. A. for the betterment, physically, mentally and spiritually, of all sorts and conditions of railroad men throughout the world.

STEEL PASSENGER CARS.*

By J. F. MacEnulty.

The development of all-steel passenger cars has been much slower than steel freight cars; presumably for the reason that steel freight cars were the outcome of a desire to carry a greater load and not increase the dead weight, a little experience having taught that 80,000 lbs. or over was too great a continual loading for a wooden car. The fact of fewer repairs and less damage in wrecks is a potent argument, and used much by steel car builders and agreed to by railway men, but had there not been so great a demand for increased loads the steel freight car pioneers would have had a sorry time.

In passenger construction the question is different. There are not the same increased loads to carry per car. If there are more passengers it means more cars. It is true that present passenger coaches are somewhat longer and much heavier, and will resist impacts that would have wrecked cars built ten or fifteen years ago. It is true, also, that they are operated at much higher speeds, and while it may seem a broad statement, our average passenger coach to-day is relatively no stronger than the cars of our forefathers. If this is doubted a perusal of the newspaper reports of a few wrecks in late years will suffice. For high-speed service it is practically essential to use a steel car, if the safety of the passengers is considered. The splinters from the old wooden warships in time of action killed more men than the cannon balls. We have been over the Spanish fleet scare for some years and do not expect any one to fire 13-in. shells at our cars, yet in a collision the conditions are not dissimilar. The force of impact will splinter the sills, posts and side plates, and a passenger caught in the wreckage has not much chance, particularly with the addition of a fire. In the steel car the passengers may suffer contusions, but these are cheaper, from a claim department standpoint, than an amputated limb. Aside from the question of accidents, steel passenger cars should be a good investment. The running repairs are less, the car being out of service a shorter time when going through the renovating process, and the steel surface is easier to finish than the wood and does not require so much care, and with steel freight car experience as a guide the life will be much longer.

The car builders are able to get cost and weight of a steel passenger coach or an interurban car very near that of a wooden car built to the same specifications. This is a decided advantage, as the railways are thus obtaining an absolutely non-combustible construction, of infinitely greater strength combined with longer life, for a small additional outlay.

For street railways and electric service in general the steel car has advantages that cannot be lightly thought of. In the first place, a so-called fireproof barn can be built, and so far as the barn itself is concerned it is, no doubt, fireproof; but unless a separate compartment is provided for each car, which is obviously impracticable, there is great danger of fire losses. In electric, subway or elevated service, where the third-rail system is used, the horror of a conflagration following a collision is eliminated. I am advised by electrical experts (although I do not wish to get into deep water on this phase of it) that in event of the insulation being worn off cables, or a trolley wire or third rail getting in contact with an all-steel car, the circuit breakers would cut out the current as soon as the resistance was overcome, which would be but a few seconds, and, in any event, the passengers would be in no danger of electrocution.

One objection to the early all-steel car was its unsightliness. It resembled a tank, and unsightly rivets and splice plates made a startling and objectionable contrast with the smooth surfaces of the wood car. This objection is obviated in the up-to-date car, as all splices and vertical rows of rivets are covered by hollow mouldings that by sight cannot be distinguished from wood, and advanced methods of construction have made the car more presentable, although the strength is unimpaired. Cars are now constructed of cold-rolled, open-hearth steel plates, pressed, and commercial shapes, while the contour and general appearance of the original wooden cars are maintained.

There is one decided advantage in these methods of construction that cannot be lightly passed over. We all know that while a good commercial grade of open-hearth steel is manufactured to-day, yet occasionally some inferior grade will get by in spite of careful inspection. The pressing operation, hot and cold, is an absolute test, and any steel that is defective in chemical or physical qualities will not hold up under the conditions, and is, of course, rejected.

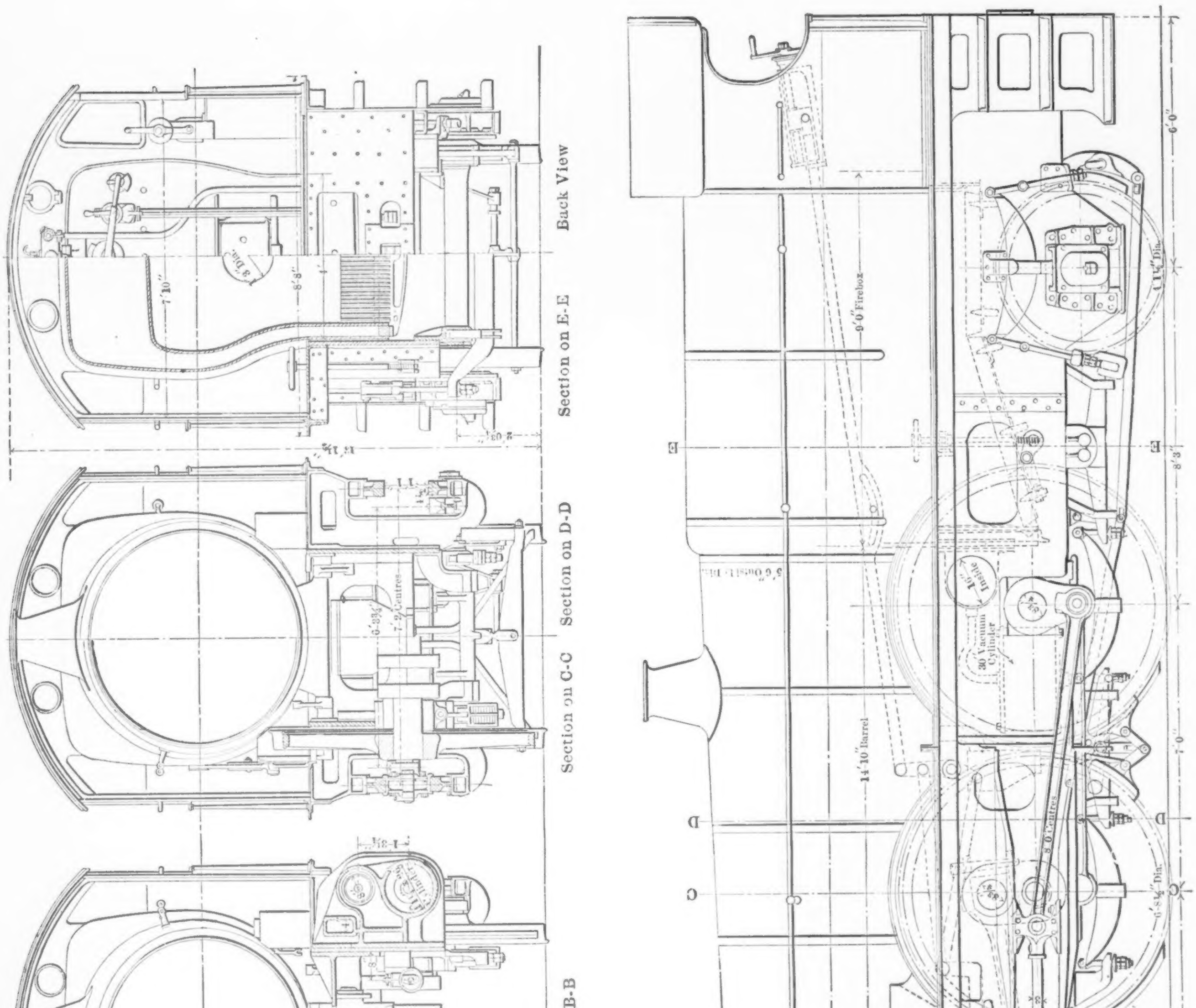
*From a paper presented before the October meeting of the New England Railroad Club.

Weight of Car and Locomotive Wheels Used Per Year.—There are in round numbers one million seven hundred and fifty thousand freight cars, forty thousand passenger cars, forty-five thousand steam locomotives, and eighty thousand electric cars in the United States. The freight cars average eight cast-iron wheels each; the passenger cars, ten; the locomotives, four pilot-wheels, six drivers, and eight tank-wheels; the electric cars average seven wheels each.

This makes a grand total of fifteen million seven hundred and seventy thousand wheels in use in this country on steam or electric roads for the pleasure or profit of the people of the United States. The total weight of these miniature atlases supporting the world of travel is in the neighborhood of five million and sixty-one thousand tons.

The average life of a cast-iron wheel on a freight car is five years, while on all other cars cast-iron lasts only a year. Steel wheels under passenger cars last about five years, and about four years under locomotives, the drivers and pilot and tank wheels having about the same lease of life.

This means that next year the railroads will buy about eighty-three thousand five hundred drivers, one hundred and sixty-seven thousand five hundred steel and steel-tired wheels, and five million three hundred and eight thousand cast-iron wheels. This is allowing also for the normal increase in number of cars in use. The total weight of iron and steel in the wheels added annually to the rolling stock of the railroads of the United States is one million eight hundred and four thousand three hundred and fifty tons.—*Exchange.*



ELEVATION AND SECTIONS OF FOUR-CYLINDER SIMPLE LOCOMOTIVE—GREAT WESTERN RAILWAY (ENGLAND).

FOUR CYLINDER SIMPLE LOCOMOTIVE—GREAT WESTERN RAILWAY.

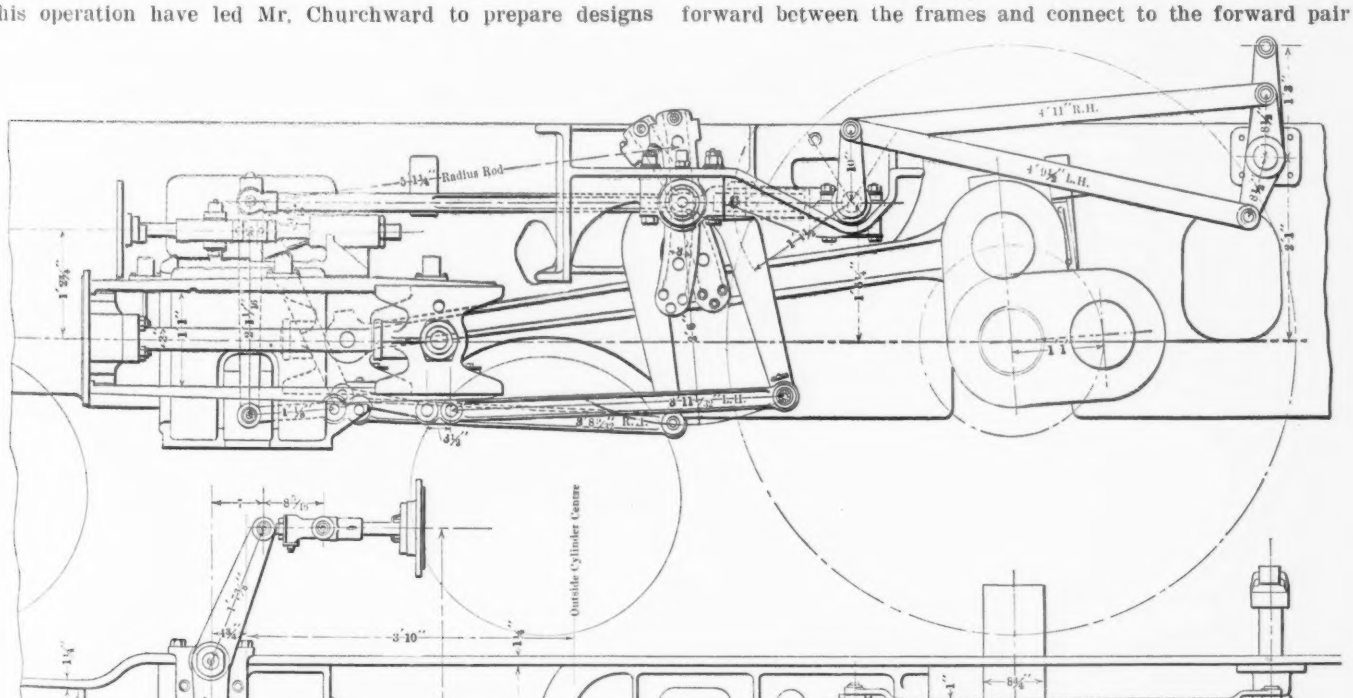
FOUR-CYLINDER SIMPLE LOCOMOTIVE.

GREAT WESTERN RAILWAY (ENGLAND).

Mr. G. J. Churchward, locomotive superintendent of the Great Western Railway of England, has recently put into operation an Atlantic type locomotive equipped with four simple cylinders, which, by his courtesy, we are able to illustrate herewith.

This locomotive was designed and built at the Swindon works of the railway and weighs 166,880 lbs. total, of which 88,704 lbs. is on drivers. The tractive effort at 85 per cent. boiler pressure by the Master Mechanics formula is 25,086 lbs. The locomotive has been operating the Plymouth Limited express of the railway and we understand the results of this operation have led Mr. Churchward to prepare designs for some 10-wheel locomotives, which will be of the same design as the Atlantic type in every respect except such minor changes as will be necessary for the addition of the extra driving wheel in place of the trailer. It is planned to have one or more of these new locomotives equipped with superheaters. It is stated that this decision to change the design to a 4-6-0 type was caused by the lack of sufficient adhesion on the Atlantic type for the heavy service demanded. An inspection of the ratios given in the table of dimensions will show the factor of adhesion to be but 3.7, which would seem to be very low, and apparently has proven to be so.

In the general arrangement of cylinders and connections this locomotive follows the DeGlehn compound, *i. e.*, the two outside cylinders are set back of the smoke box and connect to the rear pair of drivers, while the inside cylinders are set forward between the frames and connect to the forward pair

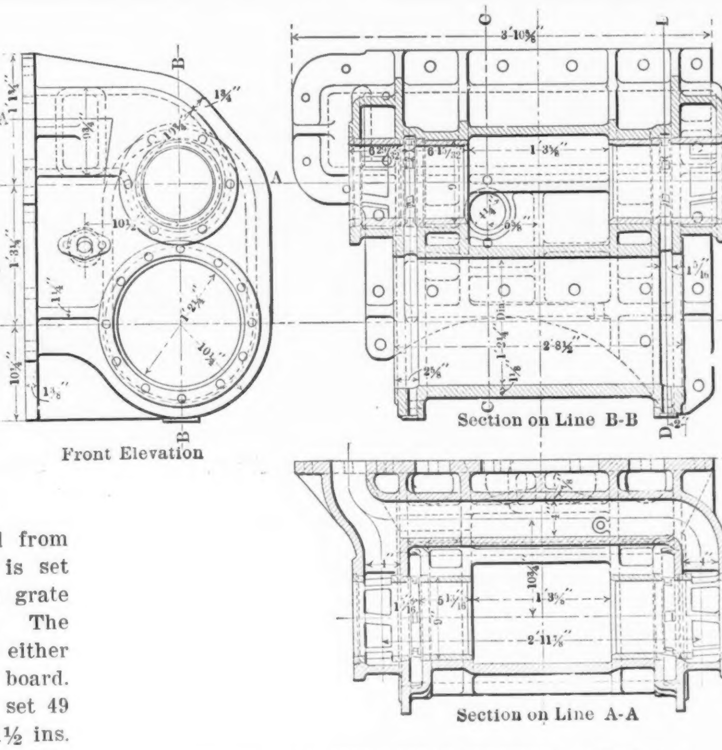


VALVE GEAR, FOUR CYLINDER SIMPLE LOCOMOTIVE—GREAT WESTERN RAILWAY.

of drivers, which have a cranked axle.

The cylinders are all 14¼ ins. in diameter and have a 26 in. stroke, making them equivalent in power to a 20.15 in. cylinder on a two-cylinder locomotive. In area of cylinder walls, however, the two cylinders on one side of course give a much greater surface than a single cylinder of equivalent power.

Outside of the cylinders and valve gear the design follows the typical English construction. The boiler is of the Belpaire type 58¾ ins. in diameter at the front end and 66 ins. in diameter at the fire box connection. It has 250-2 in. flues, each being 15 ft. 2 5-16 ins. long. The pressure is 225 lbs., which is standard on that road for all kinds of passenger power. The grate area of 27 sq. ft. seems small when compared with American practice and its ratio to the total heating surface, which is about 1 to 79, would indicate that either the coal is burned at a higher rate per sq. ft. of grate area in England than in this country or that not as much evaporation is expected from each square foot of heating surface. The fire box is set between the frames and the forward section of the grate has a very decided slope, giving a very deep throat. The dampers are arranged just below the mud ring on either side and are operated by a screw from the running board. The frames are of plate design 1¼ ins. thick and are set 49 ins. apart up to the smoke box where they narrow to 41½ ins. They are very securely and stiffly cross braced at many points throughout the length.



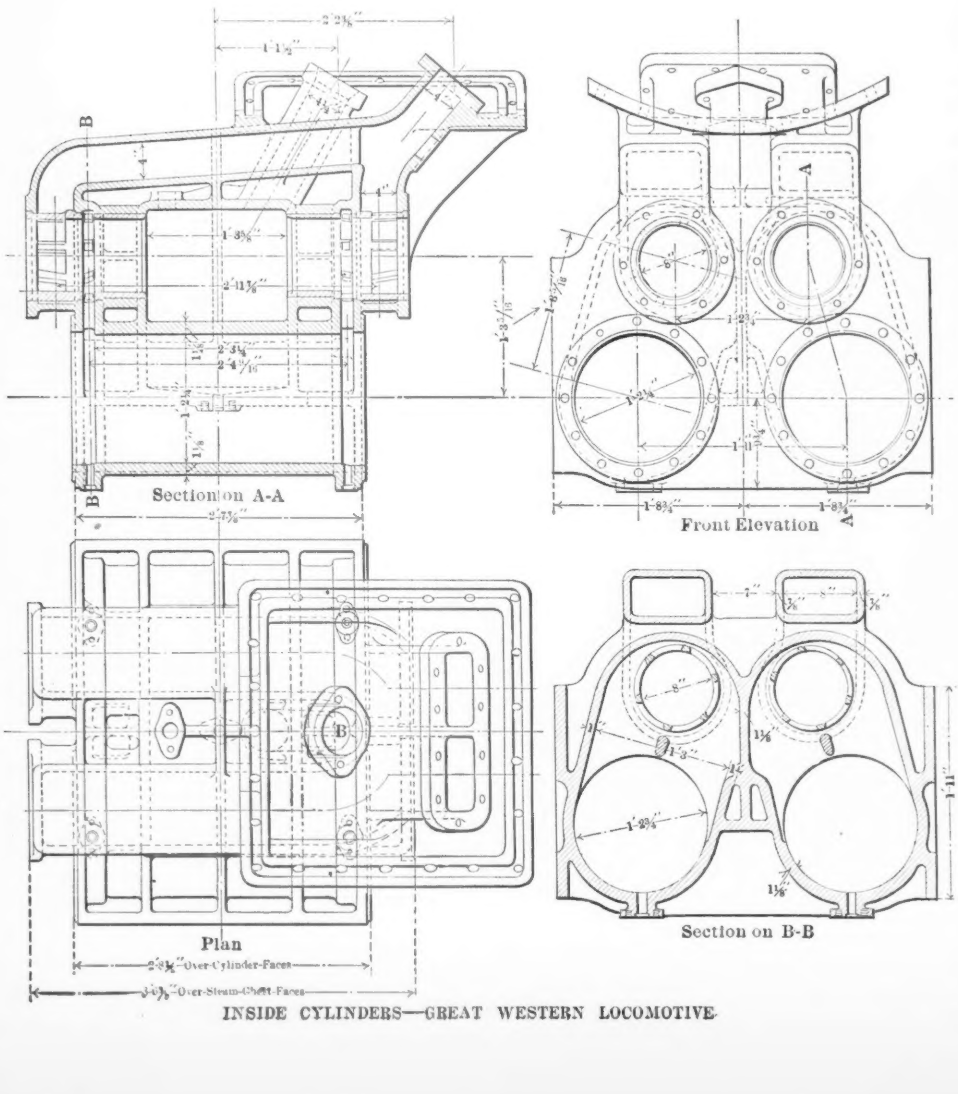
OUTSIDE CYLINDERS—GREAT WESTERN LOCOMOTIVE.

The driving wheels are 80½ ins. in diameter and the drivers and trailers on each side are equalized together, there being no cross equalizer at the trailer wheels. The braking mechanism is connected to a 30-in. vacuum cylinder located between the frames just ahead of the rear driving axle. It is connected to the driver brakes through a cross beam connecting to a toggle joint at the lower end of the hangers and to the trailer by long brake rods.

The two inside cylinders are in a single casting, which also includes the smoke box saddle. The centre of the cylinders, however, is some considerable distance ahead of the centre of the saddle, as is shown in the detailed illustration. The outside cylinders are in separate castings with their valve chambers and are secured outside of the frames. The steam and exhaust connections for the different cylinders are shown quite clearly in the general elevation. From the T head in the front end two steam pipes lead out and down on either side to just below the centre of the boiler where they branch, one part going to the inside valve chest on that side of the engine and the other to the outside valve chest, the connection in the former case being made directly to the top of the valve chest and in the latter through a separate pipe to the inside of the valve chest, passing through the frame. The exhaust passage is similar in arrangement, and branches from each valve chamber joint to a single nozzle.

The valves on all cylinders are 8-in. piston of extra length, allowing the passages to the cylinders to be practically straight. Steam is admitted on the inside and exhausted on the outside, the exhaust passage being an extension of the valve chamber, as is shown in the detail drawing.

The valve gear, of the Walschaert type, has been very simply and carefully arranged. One set of connections operates the two valves on the inside and outside cylinders on that



INSIDE CYLINDERS—GREAT WESTERN LOCOMOTIVE.

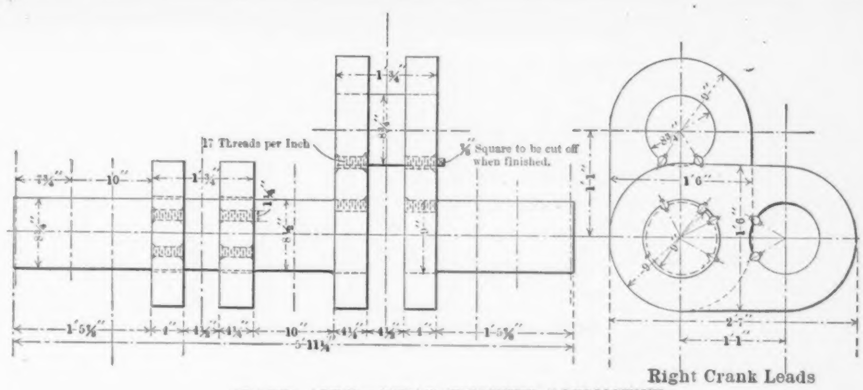
side of the locomotive. Since the inside and outside cylinders are connected at 180 degs., and the steam distribution is the same in both cylinders, the two valves move in direct opposition to each other, and hence by connecting them through a cross lever having equal arms and fulcrumed on the frame, it is possible to operate one from the other. Thus the inside valve only is connected directly to the valve gear, and operates the outside valve through a cross lever having a crosshead connection on the inside and a jointed connection to the outside valve stem. The inside cylinders are connected at an angle of 90 deg. with each other, and so, instead of taking the motion for the valve gear from an eccentric or return crank on the axle, it has been connected to the crosshead of the opposite inside cylinder. Thus there is, on each crosshead, a connection to its own combination lever, and also a connection through a rod extending back and operating the link for the valve motion of the other side of the locomotive. This method of connecting, as will be noticed, makes what corresponds to a return crank for the usual type of valve motion following the main pin in one case and preceding it in the other, and hence it reverses the position of the block in the link for the go-ahead motion in the two cases, *i. e.*, the left hand link block is at the top of its link for the go-ahead motion while the right hand block is at the bottom. This difference in reversing positions is accomplished from one reversing mechanism by having two auxiliary lift shafts operated from arms on the opposite side of the main lift shaft, which is connected directly to the screw reversing mechanism.

The crank shaft is of built-up design in nine pieces, as shown in the illustration, the sections being secured by 1¼-in. screw keys.

The tank is carried on three pairs of wheels, as is quite common in England, and has a capacity of 3,500 gallons of water.

The general dimensions, weights and ratios are as follows:

GENERAL DATA.	
Gauge	4 ft. 8½ ins.
Service	Passenger
Fuel	Bituminous Coal
Tractive effort	25,086 lbs.
Weight in working order	166,880 lbs.
Weight on drivers	88,704 lbs.
Weight on leading truck	40,096 lbs.
Weight on trailing truck	38,080 lbs.
Weight of engine and tender in working order	256,480 lbs.
Wheel base, driving	7 ft.
Wheel base, total	27 ft. 9 in.
Wheel base, engine and tender	53 ft. 6¼ in.
RATIOS.	
Weight on drivers ÷ tractive effort	3.7
Total weight ÷ tractive effort	6.64
Tractive effort x diam. drivers ÷ heating surface	943
Total heating surface ÷ grate area	78.8
Firebox heating surface ÷ total heating surface, per cent	7.2
Weight on drivers ÷ total heating surface	41.4
Total weight ÷ total heating surface	78.
Volume four cylinders	9.6 cu. ft.
Total heating surface ÷ vol. cylinders	222.
Grate area ÷ vol. cylinders	2.82
CYLINDERS.	
Number	4
Kind	Simple
Diameter and stroke	14¼ x 26 in.
VALVES.	
Kind	Piston
Diameter	8 in.
Steam ports	1¼ x 25 in.
Exhaust ports	3 x 25 in.
WHEELS.	
Driving, diameter over tires	80½ in.
Engine truck wheels, diameter	38 in.
Trailing truck wheels, diameter	49½ in.
BOILER.	
Style	Belpaire
Working pressure	225 lbs.
Outside diameter of first ring	58¾ in.
Firebox, length and width	98 7-16 x 38⅝ in.
Tubes, number and outside diameter	250—2 in.
Tubes, length	15 ft. 2 5-16 in.
Heating surface, tubes	1,988.65 sq. ft.
Heating surface, firebox	154.26 sq. ft.
Heating surface, total	2,142.91 sq. ft.
Grate area	27.07 sq. ft.
Center of boiler above rail	98 in.
TENDER.	
Weight empty	40,880 lbs.
Water capacity	3,500 gals.



CRANK AXLE—GREAT WESTERN LOCOMOTIVE.

Four-cylinder simple locomotives have been described in this journal as follows:

Belgium State Railways, 4-6-0 type with superheater, June, 1906, page 217.

Lake Shore & Michigan Southern Railway, 4-4-0 type inspection locomotive, August, 1906, page 291.

DEMAND FOR MACHINE TOOLS.—Speaking of the constant influx of orders each day which are continually extending deliveries, one of the important interests states that builders of standard tools already have so much work on hand that very few orders placed at the present time can be filled before next year. Of course, a machine can be secured here and there for several months' delivery, but it is a difficult matter to obtain a fair sized shop equipment. This condition of the market has caused prices to stiffen, and those who can promise reasonable delivery on a machine can get a substantial premium, so eager are buyers for equipment. The recent sale of the equipment of the W. S. Burn Manufacturing Company, New Haven, Conn., plainly illustrates the demand for machine tools and the prices that can be obtained for second-hand machinery. There were 547 lots sold at auction in 330 minutes, and the prices paid were in many cases higher than those for new tools. A Bath grinder bought four years ago brought $100 more than the amount paid for it at that time, and Pratt & Whitney lathes brought considerably more than the list price.—*Iron Age.*

CHANGES IN MACHINE TOOL DESIGN.—Manufacturers who would develop radically new designs are so busy filling orders for regular stock that they have little time or opportunity for developing new designs to the extent of manufacture. Many of them, we are assured, have laid out interesting departures, which they are "holding up their sleeves" for the time when business shall slack off and give them a breathing spell. It is a well-known fact that ingenuity in machine tool design, as well as in practically all other branches of machine design, is displayed to the best advantage at the time when business is dull. It is poor policy for a manufacturer to stop a profitable output simply to introduce a new idea. His customers want standard tools and want them at once. The time for experimenting is when things are slow, and we shall probably not see many radical departures from present accepted designs until that time.—*Machinery.*

MANUFACTURING IN THE UNITED STATES.—The manufactories in the United States, which turned out in 1900 $13,000,000,000 worth of products, this being then a record, have increased their output in the short period intervening more than 50 per cent., and it is calculated that their entire production for the year just closed is $18,500,000,000—*Mr. Charles H. Cochrane, in the New York Herald.*

WIND PRESSURE ON BUILDINGS.—A wind pressure of 30 lbs. per sq. ft. is called for in the New York Building Laws, for buildings more than 100 ft. high, with an allowable unit stress of 50 per cent. more than for dead or live loads. Fowler gives 20 lbs. for buildings less than 20 ft. high and 30 lbs. for buildings 60 ft. high, with no extra allowable unit stress.—*American Machinist.*

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Contributions.—*Articles relating to railway rolling stock construction and management and kindred topics, by those who are practically acquainted with these subjects, are specially desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

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CONTENTS.

Within a comparatively short time it is quite probable that the majority of the new passenger coaches built in this country will be constructed of steel. There are several reasons why this can be looked for, not the least of which is the very large number of passengers killed in recent railway wrecks, many of them by fire. A decided movement in this direction is just beginning, and while at present there are but three all-steel passenger coaches in operation, these are sufficient to show that such construction is practical, and that steel cars can be built of the same size, arrangement and comfort that is found in the modern passenger coach. Such cars can be built to weigh but little more per seated passenger than the wooden cars, and in some cases may even weigh less. At the same time they offer many times the resistance in collision and are fireproof and non-collapsible. The Harriman Lines' coach shown in our January issue weighs 107,000 lbs. and seats 70 passengers, giving a weight of 1,530 lbs. per passenger. The Long Island coach shown in this issue weighs but 1,300 lbs. per seated passenger, this weight including a 5,000-lb. storage battery equipment. The Pennsylvania Railroad has an all-steel coach in operation, which was designed and built at Altoona, and weighs 1,438 lbs. per seated passenger. This weight also includes a 5,000-lb. storage battery, as well as a copper roof, deafening floor and the P. R. R. heating and ventilating system, which are not on the other cars. It is possible to build a coach of greater length, say 70 ft., of the same design which, because of its increased seating capacity, would weigh less than 1,300 lbs. per passenger. These weights can, no doubt, be further reduced after longer experience, and in the case of large orders, where specially designed appliances can be used, the final result being a train which will weigh but little more than the present passenger train, and in view of the rapidly increasing price of lumber will probably cost but little more but will be many times as safe for the passengers.

The balancing of high-speed locomotives by the use of four cylinders connected on the quarters is undoubtedly a good thing for the locomotive and for the track, and in spite of the increased complication making it somewhat unpopular from the roundhouse and shop standpoint, it is being very generally favored in all parts of the world where progressive locomotive designers are found. Up to a comparatively recent time the balanced principle has always been employed in connection with compounding, as was quite natural, since both designs require four cylinders, and the economy to be obtained from compounding was what was chiefly desired, the advantage of the balancing being largely incidental. Recently, however, there has appeared in foreign countries several designs of locomotives which have four simple cylinders connected on the balanced principle. In this country so far but one locomotive of this kind has been built. This movement would seem to indicate that the compound is not proving to be of any great value for high-speed work under the conditions found in certain parts of England and the Continent, although it is considered with great favor in France and on certain railways in other countries; and that in these cases there is a distinct desire to retain simple cylinders while still obtaining the advantage of a balanced locomotive.

It will be remembered that one of the conclusions from the tests on the Pennsylvania Testing Plant was that, "it appears that the relative advantages to be derived from the use of the compound diminish as the speed is increased." However, since the only simple locomotives tested were two freight engines, this conclusion may not apply with equal force to passenger locomotives. We will know more about it upon the publication of the tests now being made on a simple high-speed locomotive.

From an economical point of view the four-cylinder simple as compared with the two-cylinder simple would seem to be at a very decided disadvantage, because of the largely increased area of cylinder walls, ports, steam chests, etc., all of which cause condensation, with its large loss in economy. There is also a greater number of bearing surfaces and mov-

ing parts, all of which absorb power. In the matter of condensation, which is by far the more important, there is a ready remedy in the shape of superheated steam, which also is peculiarly suited for high-speed work and tortuous passages. If the four-cylinder simple is going to compete with the four-cylinder compound in economy, it would seem to be positively essential that it use superheated steam.

If you discharge 10 per cent. of the least efficient men in your shop, or office, how much would you increase the efficiency of your force? Do you know just who the most inefficient men on your payroll are? If one of your subordinates should be promoted, or leave the service, who would you put in his place? How do you select men for promotion? These are rather pointed questions, but the success of an executive officer depends very largely on how he answers them. As we have said many times in these columns, it is far more important to have a good organization than a good equipment.

* * * * * *

A betterment engineer is responsible for the statement that if the 10 least efficient men out of every hundred in a shop, or organization, were eliminated, not only would the output not suffer, but the quality of the work would be better. His idea was that the influence of the poor men upon the others was such that the total output was decreased rather than increased by their presence. It is quite possible that the above result might be gained under the direction of a good organizer, in connection with improving the organization; at any rate, the efficiency of the shop as a whole would be raised considerably, and the statement is at least worthy of careful study.

* * * * * *

The difficulty is to build up and maintain an organization by which it is possible to determine definitely the efficiency of each man in the force, whether in the shop, in the office, or on the road. It would appear that this can only be done when each man has a definite amount of work arranged for him for each working day, and his efficiency can thus easily be determined, depending on whether he does less than or exceeds the required amount of work for a given time. Such a system would, of course, require an entirely different organization from that now existing in most shops, but if as the result of reorganizing and installing a more scientific supervision the exact efficiency of each man could be determined, the result would surely be worth striving for. In one instance where this was done the efficiency of the men was found to vary from 19 to 175 per cent. It does not require a very great imagination to see a greatly increased output in the shop, both in the amount and quality, if the men averaging, say, less than 75 or 80 per cent. in efficiency were discharged and replaced by men of average efficiency.

* * * * * *

It is quite possible that when you have read thus far you will lean back in your chair, smile a peculiar smile and then —dismiss the subject from your thoughts. Your predecessor of 10 or 15 years ago would probably have done the same thing if he had been told what he would be doing if he held your position to-day. Brigadier-General Murray, in addressing the members of the American Society of Mechanical Engineers on their recent visit to the Sandy Hook Proving Grounds, is reported to have said that five years ago the best results that could be attained with a 12-in. gun was one shot in three minutes, and the percentage of hits was 50 at a range of 4,000 to 4,500 yards. During the past year, however, more than one-half of the guns fired made a record of 100 per cent. in hits, the range being increased to 7,000 yards, and the average time between hits being reduced to less than one-half a minute. Judging from the results which have been obtained in different departments of the motive power department on three or four railroads during the past two or three years, it is not saying too much to predict that it would be possible to make almost as great a relative showing, as that made by the 12-in. gun, in the motive power departments of our railroads within the next few years. Such results, important as they may be to our railroads, especially at the present time, will not be obtained without the hearty co-operation and support of the higher officials. Neither can they be obtained if when a man makes an especially good showing on a railroad the railroads allow commercial concerns to step in and take him away from them. Surely a good man is just as valuable on a railroad as in a commercial organization. Why not pay him for it and keep him?

In the discussion on Mr. Paul R. Brooks' paper before the December meeting of the New York Railroad Club on "Railroading from a Business Point of View," some of the "unbusinesslike" proceedings in ordinary railroad life were alluded to. The general practice of cutting down requisitions—perhaps conscientiously made out—by the "man higher up" was referred to, and also the little actual knowledge of the cost of train operation by railroad officials generally. While every manufacturer knows closely the cost of the goods he is selling, it is a fact that railroads have little definite information regarding the various individual items of expense, when by definite is meant the actual expenditure per unit of work accomplished. It is true that we can divide the total figures of any one account by the engine mileage, train mileage, ton mileage, or any other factor and obtain a unit cost for the system or division, but this will not differentiate the uphill and level work, or the slow and time freights, nor can we gather any idea of the cost per horse power developed per hour, nor the factors of grade, speed, loading, etc.

We can further make comparisons between the monthly performances of locomotives in order to determine whether the coal consumption per engine or ton-mile is increasing or diminishing, but if it be increasing it is often difficult to assign a reason for it, although a perfectly logical one may exist.

The application and study required to obtain an accurate knowledge of these costs have, no doubt, been the reasons for ignoring this interesting and instructive subject, but when we consider the vast sums expended annually in producing transportation, it is evident that such studies would be extremely remunerative to the railroad companies. Some speeds and loading will cost more than others, and for this reason there must be a certain combination that will produce transportation at a minimum cost, but the discovery of this minimum cannot be made without much time and trouble. The variables are many and vary according to different laws, and each division of a road must be worked out to suit its characteristics and equipment, but when this is done the results are not uncertain.

The recent work by Mr. G. R. Henderson on the "Cost of Locomotive Operation" is the only treatise that we know of which goes into all the details of this important question, and in a plain and straightforward manner describes the methods of determining these costs. He considers the value and economical use of fuel, water, lubricants, tools, etc., as well as the cost of renewals, repairs, engineers, firemen, hostling and turning, cleaning fires, wiping, inspecting, firing up and calling, and gives various illustrations of the method of applying these data to the important question of the determination of minimum cost and maximum output.

These will very often demonstrate the fallacy of the claimed economy of the maximum train load under which a locomotive can stagger and prove that in many cases maximum output and minimum cost can both be obtained by judicious arrangement of load and speed. Mr. Henderson has had a wide experience in motive power work and engine rating in various parts of the country, and he is well qualified to interpret and discuss this question from both a theoretical and a practical point of view. We know of no work that gives as much valuable information of this kind as can be found in "Cost of Locomotive Operation," and the prospect of legislation for reducing hours of train men will make this subject still more important. If such legislation is passed and operating costs can still be maintained at a low figure by properly studying the question, the anticipated law will not be necessarily dreaded.

INSTRUCTIONS ON FIRING LOCOMOTIVES.

The following instructions to govern the firing of locomotives for the suppression of dense smoke have been put into force on the Baltimore & Ohio Railroad by Mr. J. E. Muhlfeld, general superintendent of motive power:

Engineers will be responsible for the proper operation of locomotives with respect to the handling of the reverse and throttle levers, and the supplying of feed water.

Engineers and firemen will be equally responsible for the operation of the steam blowers or smoke suppressors and for the smokeless and economical method of firing locomotives, in accordance with the following general instructions:

Before the commencement of a trip or day's work the rocking and drop gates, ash pan dampers, ash pan slides and steam jets, and grate and ash pan operating gear should be examined and tested to see that all grates set level when latched and that all parts are in good working order and in proper position. The smokebox and ash pan should be clean and the smokestack and ash pan steam blowers in good order. All necessary fire tools must be on the locomotive. The fire must be put in good condition on the grates by spreading and replenishing with fresh fuel, in small quantities at a time, until properly built up preparatory to starting with a full supply of water and steam in the boiler. The coal on the tender should be wet down.

Lumps of coal should be broken to as near the size of a man's fist as consistent before putting into the firebox.

A thin, clean fire should be maintained so that the fuel can be supplied with sufficient air through the grates for proper combustion, and produce a clear bright flame. Cross firing should be practiced to maintain an even bed, free from holes, and localized heavy or lumpy firing should be avoided as the latter method does not permit sufficient air to pass through the fuel and results in dense smoke and clinkers. The use of the rake and "puddling" of the fire should be resorted to only when absolutely necessary to spread an uneven fire caused by uneven draft or improper firing. The banking of green fuel at the furnace doors should be restricted.

The grates should be kept well supplied with coal at the sides, ends and corners of the firebox, and not more than two or three shovelfuls, each scattering the coal, should be supplied at one time. Heavy intermittent firing should be avoided. Only sufficient fire should be kept on the grates as is necessary to prevent loss of heat on account of cold air passing through the grates so freely as to reduce the temperature of the gases, and to suit the way the locomotive is being operated.

Injectors and reverse and throttle levers should be operated to favor the firing when starting from a station and on heavy pulls. The smokestack blower should be used when necessary to prevent reduction in boiler pressure, and the boiler feed should be increased to prevent release of steam through the pop valves.

Previous to the closing of the throttle valves, the fireman should apply the steam blower or smoke suppressor to such an extent as practice may demonstrate is necessary to suppress smoke. When locomotives are working steam, the smoke suppressor should be used lightly. The supply of steam to the air induction jets should be regulated by the size of the opening in gasket, so that on locomotives not equipped with brick arches there will be no tendency to blow the smoke to or through the flues.

Rocking grates must be shaken lightly and frequently, instead of violently at long intermittent periods, and, if possible, when the steam is shut off. As a general rule, all rocking grates on passenger locomotives should be shaken every 30 miles, on freight locomotives every 15 miles, and on switching locomotives every three hours. This practice will break any clinker that may be forming over or hardening between the grate openings, and will allow dead ashes to fall into the ash pans and keep the grates and fire clean. It will also allow air to pass through the grates and fire, and prevent the formation of clinker on the firebox flue and crown sheets, which occurs when air cannot get through the grates and must pass over the fire.

The practice of opening the furnace door unnecessarily should be avoided, and firemen must regulate the ash pan damper openings to suit the requirements. When locomotives are drifting the fires must be maintained in a clean and bright condition over the entire grate area, more especially at the flue sheet.

Hopper sides of ash pans must not be opened when the locomotive is running. Ash pans and fires should not be cleaned near any frog, switch, crossing, de-rail or wooden building or structure.

Certain fuels and locomotives will require special treatment, but in general the above methods are those of the most successful firemen, and the highest type of fireman is one who can maintain the working steam pressure within a range of ten pounds variation with the smallest amount of fuel and the least waste of steam through the pop valves.

Exhaust nozzle openings and draft appliances must be adjusted to suit the winter and summer conditions, and when necessary on account of change in quality or kind of fuel furnished.

Engineers must immediately report any irregularities in connection with the cleaning or building of fires at terminals. They must also report defects in connection with piston or slide valves; cylinder, or rod packing; dry, steam and exhaust pipes; smokebox draft appliances; stopped up, or leaky flues; rocking and drop grates, ash pans and dampers; smokestack and ash pan, steam blowers and smoke suppressors; and all other auxiliary equipment pertaining to the economical use of steam and fuel, and for the prevention of dense smoke. All adjustments or repairs that may be found necessary must be promptly and properly made.

The company has been and is now expending a considerable amount of money to put machinery, boilers, fireboxes, flues, grates, ash pans, and draft appliances of locomotives in a substantial condition for service, and with the grade and quality of fuel supplied, it is expected that some returns in fuel economy through proper methods will result from the operation and firing of locomotives. Passengers and the public at large are also entitled to consideration, and the elimination of dense smoke will contribute to their comfort, as well as to reduced steam failures and waste of fuel.

Master mechanics and road foremen will see that these instructions are complied with.

COMMON SENSE IN DRAFTING.—Drafting, like mathematics, is only a means to an end, and a man who makes his drawings as if they were the goal instead of a part of the course is likely to put a pile of work into them which is really useless. The sun may always shine from the upper left-hand corner at the Patent Office, and shade lines are well worth all the extra time they take on a good many jobs, but a fair amount of common sense is better than too many rules and regulations in a drafting room as well as outside of it.—*E. R. Plaisted, in Machinery.*

EXPERT KNOWLEDGE NOT EXECUTIVE ABILITY.—Either a man is competent to be put in entire charge of a department or plant, or he is not. If he is, let him run it himself. If not, you must run it for him. When subordinates are being appointed, expert special knowledge is frequently mistaken for executive ability. This throws the real load, the work of thinking, upon his superior.—*Paul R. Brooks, before the New York Railroad Club.*

GOOD ENGINEERING.—In the "One Horse Shay," Dr. Oliver Wendell Holmes, as well as the good deacon, builded better than he knew; for it should not be considered merely as a logical triumph, but as an ideal of the accuracy of engineering calculations in correctly estimating the strength of each part, and exactly providing for the depreciation of the whole work. —*Mr. C. J. H. Woodbury.*

BETTERMENT WORK ON THE SANTA FE.

To the Editor:

While your December issue presented a very full and most interesting article on the process of industrializing the Santa Fe mechanical department, yet there are some particulars involved concerning which a little further explanation would seem pertinent. For, in a study of the proposition as set forth in the article, one gains the impression that the innovations have not been confined to the methods of accomplishing the work, but go further and include departures from the usual methods of distributing accounts and exhibiting results. At first sight the results exhibited appear excellent. In fact, they may be enhanced by exhibiting them in this manner:

Year.	Engines owned.	Average tractive effort.	Repair cost per engine mile.	Repair cost per 1,000 lbs. of tractive effort per mile.
			Cents.	Cents.
1903	1,309	22,526	9.97	.4426
1904	1,433	25,578	13.42	.5247
1905	1,454	26,217	14.87	.5710
1906	1,633	27,684	11.08	.4002

The diagrams of mileage per engine failure exhibit a considerable variation between different divisions. Inasmuch as water purification has been undertaken quite extensively on the Santa Fe it would seem pertinent to state what modifying effect these plants had on the results exhibited for the various divisions.

Again, the article shows 1,454 locomotives owned in the year 1905, and 1,447 of these in service. This shows but 7 locomotives not performing service for that year. The annual report, year of 1906, shows 1,633 locomotives owned and but 1,550 in service, or 83 locomotives not performing service. Ten locomotives were sold or broken up in 1905 and 13 in 1906. From the annual reports of the Santa Fe it may be noted that in 1905 no new locomotives were put in service, but in 1906 159 arrived and were put in service. Taking 83 engines out of service as compared with the 7 of the previous year and allowing for the 3 more broken up we have 73 more locomotives out of service in 1906 than in 1905. Was not the keeping out of service of these 73 old locomotives because of the 159 new locomotives of maximum power, together with the extension of water purification, a very considerable factor in reducing the cost of engine repairs from 14.87 to 11.08 cts. per mile, without regard to the factor of shop betterment?

It was stated that in addition to the customary staff of the railway mechanical department a separate general staff of 31 men had been provided in connection with the betterment work. This would imply a still further list of clerks and various special men not mentioned. Yet a study of the annual reports for 1906 shows an increase of but $79,732 over the previous year for the superintendence of the entire mechanical department, and the included car department has been specifically excepted from the betterment benefits. Furthermore, that charges to repairs and renewals of shop machinery and tools for the entire department shows $119,146 less than the previous year, and the charges for new shop construction and equipment on existing lines shows but $380,978, or a decrease of $42,654 from the previous year. Yet we find charged to "capital account," for buildings and shops, $1,289,230, or an increase of $567,827 in 1906. Has the betterment expense been charged to this account? Or, has it been included in the $4,500,000 written off the income account for "betterments and improvements"? And were these charges to these accounts necessary because of the exhaustion of the $900,000 special betterment fund which is not mentioned in the annual reports subsequent to 1904?

Without some such distribution of the betterment expense, it is hard to understand the consistently normal costs of superintendence and of repairs and of renewals of shop machinery and tools. And furthermore, if such distribution has not been made it is difficult to account for this sudden great increase of the general accounts mentioned. While, if such distribution has been made, the consequent relief of the maintenance of equipment accounts from the cost of this special betterment work, materially alters the significance of the figures cited as showing the results of the shop betterment work.

One does not wish to appear unduly critical of the working out of a new proposition and this inquiry is merely one expression of the very general interest awakened by Mr. Emerson's work, which prompts a desire for knowledge of the modifications, if any, of such special distributions, without which the accomplishments are somewhat difficult to reconcile with the usual attainments. If there are such modifications it would be both interesting and valuable to know their extent for the use of railway men who may find it necessary to undertake similar reorganizations.

T. S. Reilly.

To the Editor:

Mr. T. S. Reilly's critical questions are pertinent. I am glad of an opportunity of giving the little further explanation for which he is justified in calling.

The criticisms are:

1. That there are departures from the usual methods of distributing accounts.
2. That water purification had modifying effects on engine failures.
3. That the purchase of new power was responsible for much of the improvement.
4. Although Mr. Reilly does not make this criticism it has been pointed out by others that in spite of betterments, locomotive maintenance, as shown by the president's report, is still high on the A., T. & S. F. Ry.

As to 1, there were absolutely no departures from the usual method of distributing accounts. All the expense, material and labor was distributed to the maintenance accounts practically wholly to supervision, locomotive maintenance and tool and machine maintenance. No part of it was included in the capital account, none of it in the $1,500,000 written up, nor any part of it to the special betterment fund.

As to 2, it is suggested that as the various divisions show great variations in improvement, the latter may be due to water purification. While treating plants have undoubtedly lessened engine failures and decreased the cost of repairs, those installed where the water was worst were in operation long before the last fiscal year.

It is unfortunate that these past records have not been tabulated with reference to this particular point, namely, the relation between engine failures due to poor water and water analysis.

Of the grand divisions of the system the one showing the greatest increase in mileage per failure and also showing the greatest mileage per failure is the Gulf and Texas grand division which has no treating plants. The two divisions of the system holding the best records both for improvement and absolutely are the Southern Kansas and the Valley division in California, each a little better than 12,000 miles. Neither of these has any treating plants.

During the fiscal year 10 treating plants were added to a previous total of 58, an increase of 17 per cent.

As to 3, the purchase of new power as a cause of decreased maintenance cost, the annual report shows:

Engines on hand June 30, 1904..................	1,433
Net engines added	21
Engines on hand June 30, 1905..................	1,454
Net engines added	179
Engines on hand June 30, 1906..................	1,633

Engines owned June 30th and engines actually in service during the year are different propositions. It happens that most of the new engines in 1905-6 came into service the latter part of the fiscal year. Reduced to a year basis the added engines amounted to 65. This number added to the previous year's total makes 1,529. The figure used—1,550—is at least 20 engines too high. Beyond the 13 scrapped as against 10 the previous year, small old timers, there were no engines retired. During the year all the shops on the system at one time or another ran short of work and every engine not condemned and scrapped was repaired.

This figure of 1,550 engines for 1906 compared to 1,447 in 1905 is the average of all locomotives owned during the year and has no reference to service. There were therefore no 79 engines out of service and only the equivalent of 52 new engines in service.

Unfortunately compound engines carrying 220 lbs. of steam, of new design and advanced type and burning oil, are not, in the first two years of their life, low in repair cost. Even fire boxes have had to be renewed on some of them. There have been other expensive repairs, consisting largely in the strengthening and replacing of weak parts. This unusual expense is inherent to any advanced new design, so new engines are not to be credited with the general reductions of maintenance expense on engines. This is not hypothesis, but based on individual engine repair costs covering four years, accounts tabulated as to classes, divisions, shop where repaired, roundhouse or back shop expense, material and labor, etc., etc.

As to 4, it has been further pointed out that even under present conditions engine maintenance costs on the Santa Fe are high, and as proof of this the figures of the president's annual report are quoted. On exactly the same basis as the previous year these

engine expense figures decreased per engine owned $1,064.07. This figure is, of course, valueless as a criterion of actual cost of engine maintenance. If a company doubled its engines and each did only half as much work the cost per engine on the above basis would be cut in two not only without any real improvement but with positive loss since twice the amount of capital would be tied up in engines, roundhouses, etc., and the engines would be fast becoming obsolescent in type. It is the practice on the Santa Fe whenever an old engine is scrapped, even if of the smallest and most antiquated type, to charge the maintenance with the cost of a new modern engine, the figure being, I believe, $18,000.

In making comparison between 1904-5 and 1905-6 it was considered much more instructive to take as a unit, engine mileage multiplied by average weight on drivers in lbs. divided by 100,000,000.

	1904-5.	1905-6.
Road units	47,855	55,994
COST PER ROAD UNIT OF VARIOUS ACCOUNTS.		
Supervision (11)	$7.68	$7.97
Locomotive Maintenance (12)—		
Labor	70.15	48.92
Material	36.77	29.69
Tools and machinery (17)	10.15	6.56
Miscellaneous (19)	17.07	10.08
Total	$141.82	$103.22
Tons of fuel per road unit	58.2	55.6

No one should wish to compare maintenance costs on a mileage basis with other roads whose engine weight is far less or even with the same road when engine weights were considerably less.

It may still be objected that this road unit cost figure is not as correct as if the road unit costs of each separate engine were summarized. This was in fact first done for a period of three years and the annual figures derived from the president's report tallied very closely.

No claim whatever is made that the betterment methods have resulted in bottom figures on the Santa Fe. None better than those connected with the work know how much can still be done. The work in question was almost wholly limited to maintenance accounts, in these accounts to three only, supervision, engines and shop tools, less than half of the whole.

The methods were in full effect only on part of the system and for only a part of the year. Had it been possible to apply them to all accounts on the whole system for a whole year the results would have been otherwise gratifying. As it is, beginning with such an insignificant item as belt maintenance, extending upwards to embrace tool account and then to the engine account, the results are an irrefutable demonstration of the practical value of certain methods as applied to railroad operation.

HARRINGTON EMERSON.

Topeka, Kan.

THE SURCHARGE PROBLEM.

To THE EDITOR:

Referring to Mr. H. Emerson's communication on page 478 of the December issue: "It requires only a simple mental calculation to show that 80 per cent. of ten men's wages is the same as 160 per cent. of five men's wages, and that the surcharges have not been increased at all." As to the confounding of surcharges with cost Mr. Morrison endeavored to show us that the surcharges are a part of the cost just as much as labor and material, and his excellent article was not written in vain. But let us confine our attention strictly to the example in the October issue, the accuracy of which has been questioned and, to make the case more concrete, let the given article be a particular type of oil can.

Says Mr. Purchasing Agent to Mr. Superintendent of Motive Power, "I can save money for the company by purchasing that can on the market in place of your manufacturing it in the shop. I can buy it for $2.50." In the natural course of events it becomes necessary for the shop superintendent to furnish the necessary figures to enable the superintendent of motive power to determine where he is at. The figures submitted (quoted from Mr. Morrison's article) are as follows:

Material	$0.85
Labor	1.25
Surcharge, 40 per cent.	.50
Total	$2.60

There exists no intention to close down the tin shop or any part of it. The problem is simply to determine whether the purchasing agent is right or wrong and to act accordingly. The result of this addition is all right as far as it goes, but it is only part of the problem.

If the 40 per cent. surcharge is not to be loaded on to the remaining work of the tin shop then it must be decided as to what new line of work will take care of it, and let us suppose water buckets are next considered, the market price of which is one dollar. Let the supposed computed cost be as follows:

Material	$0.30
Labor	.60
Surcharge, 40 per cent	.24
Total	$1.14

If we stop here our calculations show the purchasing agent to be wrong, or if the cost of the bucket figures out to be less than one dollar, the figures say he is right; but the problem is not yet complete.

If the company is using twice as many oil cans as buckets per year it can afford to buy one thousand oil cans and save ten cents per can and manufacture five hundred water buckets and lose fourteen cents per bucket. But if, on the other hand, there is a demand for twice as many buckets as cans then the tin shop had better continue to make oil cans. If the cost of the water bucket is below the market price it must even yet be determined whether or not there will be a sufficient number manufactured to take care of as large a per cent. of the tin shop's total yearly surcharge as before.

There are other items that may be worth consideration; but I believe enough has been said to show that a correct solution "beyond the shadow of a doubt" cannot be obtained by the simple addition of three quantities.

THEO. F. H. ZEALAND.

Illinois Central, Chicago.

[Editor's Note.—Mr. Zealand's point is well taken and his letter is reproduced in order to, if possible, bring this matter of the "surcharge problem" more clearly before our readers. Mr. Morrison in his article in our October journal and in a communication in our December issue has very clearly defined this question of "surcharges" and told us exactly how it has been worked out in a large shop. In outlining the method of arriving at the proper surcharge and in considering its application it is quite possible that the impression may have been conveyed, as would appear from Mr. Zealand's letter, that the matter of manufacturing or buying equipment was settled entirely by the result of these figures. There are, of course, many conditions which might arise which would warrant manufacturing a given article when it could be bought on the market at a lower cost. Mr. Morrison's idea was to show the exact method of arriving at the correct cost of an article, assuming that it would be understood that other conditions would of course be taken into consideration in determining whether to buy or manufacture a given article.]

HIGH-SPEED STEELS FOR WOODWORKING.

Builders of woodworking machinery assert that they have demonstrated to their complete satisfaction that the high-speed steels are destined to bring about radical improvements in the woodworking industry, and some even go so far as to prophesy that it will be revolutionized in the near future. The steel has been in use for these purposes for some little time, but in a limited way. Its usefulness has been hampered by a lack of knowledge of its characteristics as applied to the machining of wood, and it was only recently that tests have been concluded which give to the mechanical engineers employed by the builders of woodworking machinery something approaching exact knowledge of how the steel will work under the various conditions of this industry; where its real usefulness lies; the speeds and feeds which may be employed to best advantage; its wearing qualities and their application to cutting edges, and so on into minor details. The tests made by one of the best known and largest of the woodworking machine establishments brought out these general facts:

The rate of feed may be nearly doubled.

The cutting knives keep an edge from 3 to 10 times as long as the old steels.

The knives may be ground with a better edge.

The sharpening of knives may be done to advantage without removing them from the head.

A slower speed of knife head is entirely practicable.

Most interesting, and probably most important of all, is the knowledge that the real value of the new steels in woodwork-

ing lies in the finish given the work. The advantage in roughing out heavy work, or in other heavy duty, is secondary to that of finish. The new steels will do more work than the old, according to these tests, but it is not for this that it will be especially valued, or that it will act as a revolutionary agent, if so great a change in the industry is to be effected. These statements will sound somewhat paradoxical to those who employ the new steels in working metal, where they have been of little or no value in finishing work, though of exceedingly great importance in heavy or rapid reduction. But, according to these tests, in working wood the quality of the steel is such that, to take a test of planing as an example, instead of a succession of knife marks there is a clean, unmarred surface, with a glossiness similar to that obtained in a sanding machine. Sample boards planed at the rate of 105 ft. a minute showed this characteristic, and they included several varieties of both hard and soft woods. It should be noted that 60 ft. a minute is a high rate of feed for planing with the carbon steels.

Probably the reason for this better finish lies in the durability of the steel, which renders it possible to give the knives a keener edge, in the knowledge that it will stand up to the work for a reasonably long time. One occasionally hears of an expert woodworker who, using the ordinary knives, has planed to a finished surface, free of knife marks, but this was under exceptional circumstances, at slow feed, and perhaps with knives specially ground for the purpose. Under the new conditions, according to those who have made the tests, finished surfaces should become the universal practice in planing machines, and this at very high rates of feed. However, it must be remembered that tests are usually made under exceptional conditions, because the operators are working intelligently and even scientifically. The use of the new steel must be worked out into an accepted practice in its treatment of the steel as such, in methods of sharpening, the form of cutting edge, and in other ways that must become general in their acceptance before the steel can be applied successfully in a universal way. This will take some time, but nevertheless the development of the new practice will go on much more rapidly than formerly as soon as the manufacturers of woodworking machinery shall have adopted it as standard.

As to the use of the steel for heavy reduction purposes, there should be an advantage in its use, as in metal, but not to such great extent. The faster feed and the better ability to maintain an edge will count for a great deal, but it should be stated that in the way of rapid reduction the old steels have been entirely satisfactory, and seldom has a task been found beyond the temper of the cutting blades. For special purposes, doubtless, the new steel will be valuable, as, for instance, in the machining of very hard woods. As for the form of the knives, the tool holder is coming into vogue for the purpose, the blades consisting of thin, narrow strips securely clamped to the head.—*The Iron Age.*

CAR AND LOCOMOTIVE OUTPUT IN 1906.

Official returns from the 38 car-building companies on the North American continent (estimating two small plants not heard from), give the total number of railroad cars built during 1906 as 243,670. This includes subway and elevated cars, but does not include electric street and interurban cars. In addition to this total, the railroads have built in their own shops a large number of cars, both freight and passenger, but no estimate has been made of these. Of the manufacturers' output, 240,503 cars were for freight service, and 3,167 for passenger service; 236,451 were for domestic use, and 7,219 for export. Canada built 7,059 freight cars and 83 passenger cars, and Mexico built 203 freight and 6 passenger cars. The increase in the Canadian output over last year is 230 per cent. All of the builders have shared alike in the tremendous increase. A number of the companies reported this year the number of unfilled orders on their books. Most of them have more cars on order than they have built during the entire year with their plants working at their maximum capacity. This is the best indication of the enormous demand for rolling stock and the utter inability of the railroads to get the cars they need. The following table shows the *Railroad Gazette's* compilation of the number of cars built during the last eight years; totals for 1905 and 1906, including Canada:

Year.	Freight.	Passenger.	Total.
1899	119,886	1,305	121,191
1900	115,631	1,636	117,267
1901	136,950	2,055	139,005
1902	162,599	1,948	164,547
1903	153,195	2,007	155,202
1904	60,806	2,144	62,950
1905	165,455	2,551	168,006
1906	240,503	3,167	243,670

The locomotive output is quite as phenomenal. The 12 builders in the United States and Canada turned out 6,952 locomotives during the year, of which 6,232 were for domestic use and 720 for export. This is an increase of 27.3 per cent. over last year's total of 5,491. These figures do not include locomotives built in railroad shops, or locomotives rebuilt or repaired. There were built 237 electric locomotives and 292 compounds, as against 140 and 177, respectively, last year. The Canadian output was 217. The following table shows the number of locomotives built during the last 15 years; totals for 1905 and 1906, including Canada:

1892	2,012	1897	1,251	1902	4,070
1893	2,011	1898	1,875	1903	5,152
1894	695	1899	2,473	1904	3,441
1895	1,101	1900	3,153	1905	5,491
1896	1,175	1901	3,384	1906	6,952

The cost of cars and locomotives has increased considerably during the year. Estimating the average cost of freight cars at $1,050, the total spent for freight cars amounts to $252,525,000. For passenger cars at $8,000, the cost was $25,336,000, and for locomotives at $14,500, the cost was $101,384,000. The total amount spent by the railroads for new rolling stock and motive power thus approximates $380,000,000, an increase over last year of about 45 per cent.—*Railroad Gazette.*

Overheating High Speed Tools in Grinding.—The writer trusts that he has made the fact clear that the property of "red hardness" in tools is seriously impaired by even temporarily raising their temperature beyond 1,240 deg. F. He ventures to say that fully half of the high-speed tools now in use in the average machine shop have been more or less injured and are therefore lacking in uniformity, owing to their having been overheated during the operation of grinding. Even when a heavy stream of water is thrown upon the nose of the tool throughout the operation of grinding, tools can be readily overheated by forcing the grinding or by allowing the tool to fit against the grindstone. This injury is all the more serious because there is no way of detecting it except by finding through actual use that the tool has become of inferior quality. The writer has frequently seen tools which were ground under a heavy stream of water heated so that the metal close to their cutting edges showed a visible red heat. Occasionally tools are also overheated by running at too high speeds in the lathe. In this case, however, the injury to the tool is perfectly apparent, and therefore not so serious as the overheating on the emery wheel. A tool which has been overheated either in grinding or in the machine can be again rendered first-class in quality by grinding it from 1-16 to 3-16 in. back from the cutting edge and down from the lip surface, because overheating from grinding or running in the lathe rarely penetrates beyond this depth. The best advice that we can give to those desirous of having uniform tools is not to experiment with new brands of tool steel. Adopt once for all the best that can be had at the time the choice is made, and then see to it that the smith heats each tool uniformly and rapidly close to the melting point, and that the grinder does not overheat the tool in sharpening it. Watch the smith and the grinder; do not change the make of the tool steel.—*Mr. Fred. W. Taylor, before the A. S. M. E.*

ALTERING LOCOMOTIVE WHEEL PRESSURES.

W. H. VAN DRUTEN, M. E.

It is occasionally found advisable after a locomotive has been in service for some time to make a change in the wheel pressures. This can, of course, be done within limits by a change in the equalizer and spring rigging, but the "cut and try" method often used in doing this is a very slow and tedious process. By the application of a little elementary mathematics the problem becomes simple and exact, as is shown in the following example:

Take, for instance, a 4—6—0 engine, having the following wheel pressures:

On front drivers	53,000 lbs.
On middle drivers	46,000 lbs.
On back drivers	49,200 lbs.
On truck	24,000 lbs.

The last-named weight being too small, as it does not insure sufficient guiding power to the locomotive running through

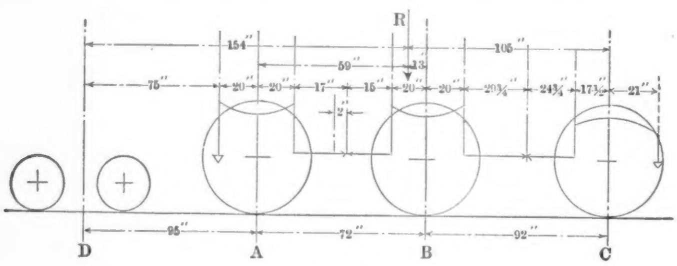


FIG. 1.

curves, it is required to increase this weight by moving the fulcrum of the front equalizer.

Let us move the fulcrum 2 ins. back, making the equalizer arms 17 ins. and 15 ins., respectively, instead of 15 ins. and 17 ins., respectively.

Subtracting from the new wheel pressures the weights of the driving wheels, axles, boxes and also the weight of the truck itself, which are

Front drivers	8,200 lbs.
Middle drivers	10,700 lbs.
Back drivers	8,200 lbs.
Truck	10,000 lbs.

and calling the remaining weights A, B, C and D, respectively, we get the equation, $A+B+C+D=135{,}100$ .... (1)

Considering the equilibrium of the front equalizer we get

$$\frac{A}{2} \times 17 = \frac{B}{2} \times 15 \text{ or}$$

$$17\ A = 15\ B \quad \ldots\ldots (2)$$

The second equalizer gives the equation

$$29\tfrac{3}{4} \times B\ \frac{1}{2} = 24\tfrac{3}{4} \times \frac{21}{38\tfrac{1}{2}}\ C \quad \ldots\ldots (3)$$

From the location and size of the weights A, B, C and D before the changing, being, respectively, 44,800 lbs., 35,300 lbs., 41.000 lbs. and 14,000 lbs., we can find the place of the resultant, or, in other words, the place of the vertical line in which the center of gravity of the weight of the engine above drivers and truck is located. This is found to be at R, at the distances from centers of drivers and truck, as shown in the diagram. (The distance of this center of gravity above rail is immaterial here.)

This point being the same before and after the change, it is now possible to form the 4th equation, expressing the condition that the sum of the moments to the left of this point must be equal to the total of the moments to the right, viz.:

$$154D+59\ A=13B+105C \quad \ldots\ldots (4)$$

From these four equations we can determine the four unknown quantities A, B, C and D, as follows:

From (4) and (1) we solve for A and equalize the expressions:

$$A = \frac{13B+105C-154D}{59} = 135100-B-C-D$$

or $13B+105C-154D=7970900-59B-59C-59D$

$72B=7970900-164C+95D$

$B=110707-2.278C+1.32D$

Equalizing this expression to the value of B from (3)

$110707-2.278C+1.32D=0.908C$

$110707+1.32D=3.186C$

$C=34748+0.414D$

Solving A from (1) and (2) and equalizing the expressions

$$A=135{,}100\text{-}B\text{-}C\text{-}D=\frac{15}{17}B$$

or $2296700-17B-17C-17D=15B$

$2296700-17C-17D=32B$

$71772-.531C-.531D=B$

Putting this equal to the value of B from (3)

$71772\text{-}.531C\text{-}.531D=0.908C$

or $71772\text{-}.531D=1.439C$

$C=49882\text{-}.369D$

By equalizing the two values found for C

$34748+.414D=49882-.369D$

from which $D=19{,}328$ lbs.

Further having found $C=34748+.414D$

we get $C=42{,}740$ lbs.

From $B=0.908C$ we get $B=38{,}800$ lbs., and from (2)

$$A=\frac{15}{17}B$$

$A=34{,}230$ lbs.

Adding now the weights of wheels, axles and boxes to the weights A, B and C, and the weight of the truck to D, we get the new wheel pressures.

On front drivers	34,230+ 8,200=42,430 lbs.
On middle drivers	38,880+10,700=49,500 lbs.
On back drivers	42,740+ 8,200=50,940 lbs.
On truck	19,328+10,000=29,328 lbs.

Comparing these figures with the original wheel pressures, we see that we gain

On truck	29,328—24,000=5,328 lbs.
On middle drivers	49,500—46,000=3,500 lbs.
On back drivers	50,940—49,200=1,740 lbs.
	10,568 lbs.

and lose on the first pair of drivers 53,000—42,430=10,570 lbs.

This gives a better distribution of weights, as there is more weight on truck and on the main drivers. In some cases a slight addition to the weight on the truck may be obtained by lengthening the spring hangers of the front pair of drivers and shortening them on the back pair, which has a tendency to tip the boiler down in front, turning it round its center of gravity. This allows more water to go to the front, lightening it at the same time at the back. Care, of course, must be taken to make the necessary changes in the springs, according to the new loads coming on them.

In a similar way the question of traction increasers may be treated. To illustrate this, take the case of the New York Central 4—4—2 locomotive, quoted by Mr. G. R. Henderson in his book, "Locomotive Operation," on pages 287-291:

This engine has a device for pushing down the back equalizer at a point 5½ ins. ahead of the fulcrum C, so forming a new fulcrum instead. (See Fig. 2.)

Here we have the wheel pressures:

On trailers	38,500 lbs.
On back drivers	47,500 lbs.
On front drivers	47,500 lbs.
On truck	42,500 lbs.

Taking off the weights of wheels, axles and boxes, and that of the truck itself, gives the weights

Above trailers	38,500— 2,500=36,000 lbs.
Above back drivers	47,500— 7,500=40,000 lbs.
Above front drivers	47,500— 7,500=40,000 lbs.
Above truck	42,500—12,500=30,000 lbs.
Total	146,000 lbs.

Calling the new weights above trailers, drivers and truck, after the traction increasers have pushed the equalizer free from the fulcrum C; A, B, B and C, we can write our equations as follows: (the weights above the driving axles being evident-

ly the same, on account of the equal arms of the equalizer between them):

$$A+2B+C=146000 \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\frac{A}{2} \times 39\tfrac{1}{2}=\frac{B}{2} \times 25\tfrac{1}{2} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The resultant of the four pressures (above trailers, drivers and truck) we find to be located at R at the distances from the respective centers as noted in the diagram.

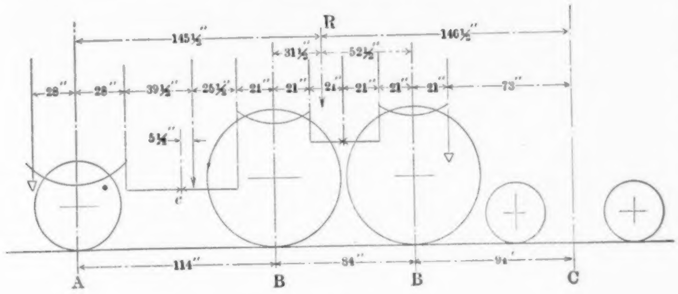


FIG. 2.

This location of the center of gravity not being changed, we have the equation of the moments:

$$145\tfrac{1}{2}A+31\tfrac{1}{2}B=52\tfrac{1}{2}B+146\tfrac{1}{2}C \;\ldots\ldots\ldots\ldots\ldots (3)$$

From these three equations we can solve A, B, and C.

Taking the values of A from (3) and (1) and equalizing we get

$$A=\frac{21B+146\tfrac{1}{2}C}{145\tfrac{1}{2}}=146000-2B-C$$

or $21B\times146\tfrac{1}{2}C=21240000-291B-145\tfrac{1}{2}C$
or $312B=21240000-292C$
and $B=68100-.936C$

Taking the value of A from (2) and (1) and equalizing we have:

$$A=\frac{25\tfrac{1}{2}B}{39\tfrac{1}{2}}=146000-2B-C$$

or $25\tfrac{1}{2}B=5766500-79B-39\tfrac{1}{2}C$
or $104\tfrac{1}{2}B=5766500-39\tfrac{1}{2}C$
and $B=55190-.378C$

Equating these two values of B gives

$68100-.936C-=55190-.378C$

from which C=23,130 lbs.

From B=68,100—0.936C.

B=46,450 lbs.

From equation (2) A=29,970 lbs.

Adding again the weights of axles, wheels and truck, we get the new total wheel pressures.

On trailers	29,970+ 2,500=32,470 lbs.
On back drivers	46,450+ 7,500=53,950 lbs.
On front drivers	46,450+ 7,500=53,950 lbs.
On truck	23,130+12,500=35,630 lbs.

On comparing with the original wheel pressures we find that we gain

On drivers 2 x (53,950—47,500)=2 x 6,450=12,900 lbs.

and we lose on front truck

42,500—35,630=6,870 lbs.

and on trailers:

39,500—32,470=6,030 lbs.

Total.......12,900 lbs.

By this method questions of changes in equalizer and spring riggings become very simple, and much time and inconvenience will be saved by solving them in this direct way.

In general, a small amount of lower mathematics, that every technical man is familiar with, may, in many cases, when applied in the right way and the right place, serve to a better understanding of apparently obscure complications.

The largest pin factory in the world is said to be that at Birmingham, England, which has a daily output of 37,000,000 pins.—*Iron Age.*

THE ART OF CUTTING METALS.

The presidential address of Mr. Fred. W. Taylor, before the American Society of Mechanical Engineers, is probably the most valuable paper ever presented before that society. It is a record of experiments extending over a period of 26 years, and its value lies not alone in the data presented concerning the cutting of metals, but also in the fact that, as stated by Mr. Calvin W. Rice in the discussion, it is a record of many incidents to the introduction of the Taylor system.

The address contains 250 pages of text, in addition to 140 drawings and tables, and we can therefore do little more than attempt to convey an idea of its scope. We would, however, urge those who are interested in shop management and operation to obtain a copy and study it carefully. The following abstract is taken from the first part, which gives a history of the experiments. The second part considers the results of the investigation in detail.

"The experiments described in this paper were undertaken to obtain a part of the information necessary to establish in a machine shop our system of management, the central idea of which is: (A) To give each workman each day in advance a definite task, with detailed written instructions, and an exact time allowance for each element of work. (B) To pay extraordinarily high wages to those who perform their tasks in the allotted time, and ordinary wages to those who take more than their time allowance. There are three questions which must be answered each day in every machine shop by every machinist who is running a metal cutting machine, such as a lathe, planer, drill press, milling machine, etc., namely:

"*a.* What tool shall I use?

"*b.* What cutting speed shall I use?

"*c.* What feed shall I use?

"Our investigations, which were started 26 years ago with the definite purpose of finding the true answers to these questions under all the varying conditions of machine shop practice, have been carried on up to the present time with this as the main object still in view.

Roughing Work Considered Exclusively.

"The writer will confine himself almost exclusively to an attempted solution of this problem as it affects 'roughing work'; *i. e.*, the preparation of the forging or casting for the final finishing cut, which is taken only in those cases where great accuracy or high finish is called for. Fine finishing cuts will not be dealt with. Our principal object will be to describe the fundamental laws and principles which will enable us to do 'roughing work' in the shortest time, whether the cuts are light or heavy, whether the work is rigid or elastic, and whether the machine tools are light and of small driving power, or heavy and rigid with ample driving power. In other words, our problem is to take the work and machines as we find them in a machine shop, and by properly changing the countershaft speeds, equipping the shop with tools of the best quality and shapes, and then making a slide rule for each machine to enable an intelligent mechanic with the aid of these slide rules to tell each workman how to do each piece of work in the quickest time.

"It may seem strange to say that a slide rule enables a good mechanic to double the output of a machine which has been run, for example, for 10 years by a first-class machinist having exceptional knowledge of and experience with his machine and who has been using his best judgment. Yet our observation shows that, on the average, this understates the fact. To make the reason for this more clear, it should be understood that the man with the aid of his slide rule is called upon to determine the effect which each of the 12 elements or variables given below has upon the choice of cutting speed and feed; and it will be evident that the mechanic, expert or mathematician does not live who, without the aid of a slide rule or its equivalent, can hold in his head these 12 variables and measure their joint effect upon the problem. These 12 elements or variables are as follows:

a. The quality of the metal which is to be cut.
b. The diameter of the work.

c. The depth of the cut.
d. The thickness of the shaving.
e. The elasticity of the work and of the tool.
f. The shape or contour of the cutting edge of the tool, together with its clearance and lip angles.
g. The chemical composition of the steel from which the tool is made, and the heat treatment of the tool.
h. Whether a copious stream of water, or other cooling medium, is used on the tool.
j. The duration of the cut—*i. e.*, the time which a tool must last under pressure of the shaving without being reground.
k. The pressure of the chip or shaving upon the tool.
l. The changes of speed and feed possible in the lathe.
m. The pulling and feeding power of the lathe.

"Broadly speaking, the problem of studying the effect of each of the above variables upon the cutting speed and of making this study practically useful may be divided into four sections, as follows:

"(A) The determination by a series of experiments of the important facts or laws connected with the art of cutting metals.

"(B) The finding of mathematical expressions for these laws which are so simple as to be suited to daily use.

"(C) The investigation of the limitations and possibilities of metal cutting machines.

"(D) The development of an instrument (a slide rule) which embodies, on the one hand, the laws of cutting metals, and on the other the possibilities and limitations of the particular lathe or planer, etc., to which it applies, and which can be used by a machinist without mathematical training to quickly indicate in each case the speed and feed which will do the work quickest and best."

How the Investigation Was Carried On.

The experiments were started in 1880 and continued until 1899 in the works of the Midvale Steel Company, with the aid and encouragement of Mr. William Sellers, at that time its president. At various times since then they have been carried on in the works and at the expense of the Cramps' Shipbuilding Company, William Sellers & Co., the Link-Belt Engineering Company, Dodge & Day and the Bethlehem Steel Company. Most of the results of the experiments have been kept secret up to the present time, and have been given to the different companies in consideration of still further carrying on the work.

Those who were closely associated with Mr. Taylor in carrying on the investigations are Mr. G. M. Sinclair, Mr. H. L. Gantt, Mr. Maunsel White and Mr. Carl G. Barth.

"In carrying on this work more than 10 machines have been fitted up at various times with special driving apparatus and the other needed appliances, all machines used since 1894 having been equipped with electric drives, so as to obtain any desired cutting speed. The thoroughness with which the work has been done may perhaps be better appreciated when it is understood that we have made between 30,000 and 50,000 recorded experiments, and many others of which no record was kept. In studying these laws we have cut up into chips with our experimental tools more than 800,000 lbs. of steel and iron. More than 16,000 experiments were recorded in the Bethlehem Steel Company. We estimate that up to date between $150,000 and $200,000 have been spent upon this work, and it is a very great satisfaction to feel that those whose generosity has enabled us to carry on the experiments have received ample return for their money through the increased output and the economy in running their shops which have resulted from our experiments.

"It seems to us that the time has now come for the engineering fraternity to have the results of our work, in spite of the fact that this will cut off our former means of financing the experiments. However, we are in hopes that the money required to complete this work may be obtained from some other source."

Summary of Results.

Following is a chronology of some of the more important discoveries made:

"In 1881, the discovery that a round-nosed tool could be run under given conditions at a much higher cutting speed and therefore turn out much more work than the old-fashioned diamond-pointed tool.

"In 1881, the demonstration that, broadly speaking, the use of coarse feeds, accompanied by their necessarily slow cutting speeds, would do more work than fine feeds with their accompanying high speeds.

"In 1883, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from the steel forging by the tool, would permit an increase in cutting speed, and, therefore, in the amount of work done of from 30 to 40 per cent. In 1884 a new machine shop was built for the Midvale Steel Works, in the construction of which this discovery played a most important part; each machine being set in a wrought iron pan in which was collected the water (supersaturated with carbonate of soda to prevent rusting), which was thrown in a heavy stream upon the tool for the purpose of cooling it. The water from each of these pans was carried through suitable drain pipes beneath the floor to a central well, from which it was pumped to an overhead tank, from which a system of supply pipes led to each machine. Up to that time the use of water for cooling tools was confined to small cans or tanks, from which only a minute stream was allowed to trickle upon the tool and the work, more for the purpose of obtaining a water finish on the work than with the object of cooling the tool; and, in fact, these small streams of water are utterly inadequate for the latter purpose. So far as the writer knows, in spite of the fact that the shops of the Midvale Steel Works until recently have been open to the public since 1884, no other shop in this country was similarly fitted up until the Bethlehem Steel Company in 1899, with the one exception of a small steel works which was an offshoot in personnel from the Midvale Steel Company.

"In 1883, the completion of a set of experiments with round-nosed tools; first, with varying thicknesses of feed when the depth of the cut was maintained constant; and, second, with varying depths of cut while the feed remained constant, to determine the effect of these two elements on the cutting speed.

"In 1883, the demonstration of the fact that the longer a tool is called upon to work continuously under pressure of a shaving, the slower must be the cutting speed, and the exact determination of the effect of the duration of the cut upon the cutting speed.

"In 1883, the development of formulæ which gave mathematical expression to the two broad laws above referred to. Fortunately, these formulæ were of the type capable of logarithmic expression, and therefore suited to the gradual mathematical development extending through a long period of years, which resulted in making our slide rules and solved the whole problem in 1901.

"In 1883, the experimental determination of the pressure upon the tool required on steel tires to remove cuts of varying depths and thickness of shaving.

"In 1883, the starting of a set of experiments on belting described in a paper published in *Transactions*, Vol. 15 (1904).

"In 1883, the measurement of the power required to feed a round-nosed tool with varying depths of cut and thickness of shaving when cutting a steel tire. This experiment showed that a very dull tool required as much pressure to feed it as to drive the cut. This was one of the most important discoveries made by us, and as a result all steel-cutting machines purchased since that time by the Midvale Steel Company have been supplied with feeding power equal to their driving power, and very greatly in excess of that used on standard machine tools.

"In 1884, the design of an automatic grinder for grinding tools in lots and the construction of a toolroom for storing and issuing tools ready ground to the men.

"From 1885 to 1889, the making of a series of practical tables for a number of machines in the shops of the Midvale Steel Company, by the aid of which it was possible to give definite tasks each day to the machinists who were running machines, and which resulted in a great increase in their output.

"In 1886, the demonstration that the thickness of the chip or layer of metal removed by the tool has a much greater effect upon the cutting speed than any other element, and the practical use of this knowledge in making and putting into everyday use in our shops a series of broad-nosed tools, which enabled us to run with a coarse feed at as high a speed as had been before attained with round-nosed tools when using a fine feed, thus substituting, for a considerable portion of the work, ***coarse feeds and high speeds*** for our old maxim of coarse feeds and slow speeds.

"In 1894 and 1895, the discovery that a greater proportional gain could be made in cutting soft metals through the use of tools made from self-hardening steels than in cutting hard metals, the gain made by the use of self-hardening tools over tempered tools in cutting soft cast-iron being almost 90 per cent., whereas the gain in cutting hard steels or hard cast-iron was only about 45 per cent. Up to this time the use of Mushet and other self-hardening tools

had been almost exclusively confined to cutting hard metals, a few tools made of Mushet steel being kept on hand in every shop for special use on hard castings or forgings which could not be cut by the tempered tools. This experiment resulted in substituting self-hardening tools for tempered tools for all 'roughing work' throughout the machine shop.

"In 1894 and 1895 the discovery that in cutting wrought iron or steel a heavy stream of water thrown upon the shaving at the nose of the tool produced a gain in cutting speed of self-hardening tools of about 33 per cent. Up to this time the makers of self-hardening steel had warned users not to use water on the tools.

"From 1898 to 1900, the discovery and development of the Taylor-White process of treating tools, namely, the discovery that tools made from chromium-tungsten steels when heated to the melting point would do from two to four times as much work as other tools.

"In 1899-1902, the development of our slide rules, which are so simple that they enable an ordinary workman to make practical and rapid everyday use in the shop of all the laws and formulæ deduced from our experiments.

"In 1906, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from cast-iron by the tool would permit an increase in cutting speed, and therefore in the amount of work done, of 16 per cent.

"In 1906, the discovery that by adding a small quantity of vanadium to tool steel to be used for making modern high-speed chromium-tungsten tools heated to near the melting point, the hardness and endurance of tools, as well as their cutting speeds, are materially improved.

The Slide Rule and Its Application.

"While many of the results of these experiments are both interesting and valuable, we regard as of by far the greatest value that portion of our experiments and of our mathematical work which has resulted in the development of the slide rules; *i. e.*, the patient investigation and mathematical expression of the exact effect upon the cutting speed of such elements as the shape of the cutting edge of the tool, the thickness of the shaving, the depth of the cut, the quality of the metal being cut and the duration of the cut, etc. This work enables us to fix a daily task with a definite time allowance for each workman who is running a machine tool, and to pay the men a bonus for rapid work.

"The gain from these slide rules is far greater than that of all the other improvements combined, because it accomplishes the original object, for which in 1880 the experiments were started, *i. e.*, that of taking the control of the machine shop out of the hands of the many workmen and placing it completely in the hands of the management, thus superseding 'rule of thumb' by scientific control.

"It must be said, therefore, that to get any great benefit from the laws derived from these experiments our slide rules must be used, and these slide rules will be of but little, if any, value under the old style of management, in which the machinist is left with the final decision as to what shape of tool, depth of cut, speed and feed he will use. The slide rules cannot be left at the lathe to be banged about by the machinist. They must be used by a man with reasonably clean hands, and at a table or desk, and this man must write his instructions as to speed, feed, depth of cut, etc., and send them to the machinist well in advance of the time that the work is to be done. Even if these written instructions are sent to the machinist, however, little attention will be paid to them unless rigid standards have been not only adopted, but enforced, throughout the shop for every detail, large and small, of the shop equipment, as well as for all shop methods.

"Unfortunately, those fundamental ideas upon which the new task management rests mainly for success are directly antagonistic to the fundamental ideas of the old type of management. To give two out of many examples: Under our system the workman is told minutely just what he is to do and how he is to do it; and any improvement which he makes upon the orders given him is fatal to success. While, with the old style, the workman is expected constantly to improve upon his orders and former methods, under our system any improvement, large or small, once decided upon goes into immediate use, and is never allowed to lapse or become obsolete, while under the old system the innovation, unless it meets with the approval of the mechanic (which it never does at the start) is generally for a long time, at least, a positive impediment to success. Thus many of those elements which are mainly responsible for the success of our system are failures and a positive clog when grafted on the old system.

"For this reason the really great gain which will ultimately come from the use of these slide rules will be slow in arriving —mainly, as explained, because of the revolutionary changes needed for their successful use—but it is sure to come in the end.

"A long time will be required in any shop to bring about this radically new order of things; but in the end the gain is so great that I say without hesitation that there is hardly a machine shop in the country whose output cannot be doubled through the use of these methods. And this applies not only to large shops, but also to comparatively small establishments. In a company whose employees all told, including officers and salesmen, number about 150 men, we have succeeded in more than doubling the output of the shop, and in converting an annual loss of 20 per cent. upon the old volume of business into an annual profit of more than 20 per cent. upon the new volume of business, and at the same time rendering a lot of disorganized and dissatisfied workmen contented and hard working, by insuring them an average increase of about 35 per cent. in their wages. And I take this opportunity of again saying that those companies are indeed fortunate who can secure the services of men to direct the introduction of this type of management who have had sufficient training and experience to insure success.

Standardization Means Simplification.

"Too much emphasis cannot be laid upon the fact that standardization really means simplification. It is far simpler to have in a standardized shop two makes of tool steel than to have 20 makes of tool steel, as will be found in shops under the old style of management. It is far simpler to have all of the tools in a standardized shop ground by one man to a few simple but rigidly maintained shapes than to have, as is usual in the old style shop, each machinist spend a portion of each day at the grindstone, grinding his tools with radically wrong curves and cutting angles, merely because bad shapes are easier to grind than good. Hundreds of similar illustrations could be given showing the true simplicity (not complication) which accompanies the new type of management.

"There is, however, one element in which the new type of management to all outward appearance is far more complicated than the old—namely, no standards and no real system of management can be maintained without the supervision, and, what is more, the hard work of men who would be called by the old style of management supernumeraries or non-producers. The man who judges of the complication of his organization only by looking over the names of those on the payroll and separating the so-called non-producers from the producers, finds the new style of management more complicated than the old.

"No one doubts for one minute that it is far simpler to run a shop with a boiler, steam engine, shafting, pulleys and belts than it would be to run the same shop with the old-fashioned foot power, yet the boiler, steam engine, shafting, pulleys and belts require, as supernumeraries or non-producers on the payroll, a fireman, an engineer, an oiler and often a man to look after belts. The old style manager, however, who judges of complication only by comparing the number of non-producers with that of the producers, would find the steam engine merely a complication in management. The same man, to be logical, would find the whole drafting force of an engineering establishment merely a complication, whereas in fact it is a great simplification over the old method.

Individual Motor Drive.

"There is one recommendation, however, in modern machine shop practice in making which the writer will probably be accused of being old-fashioned or ultra-conservative. Of late

years there has been what may be almost termed a blind rush on the part of those who have wished to increase the efficiency of their shops toward driving each individual machine with an independent motor. The writer is firmly convinced through large personal observation in many shops and through having himself systematized two electrical works, that in perhaps three cases out of four a properly designed belt drive is preferable to the individual motor drive for machine tools. There is no question that through a term of years the total cost, on the one hand, of individual motors and electrical wiring, coupled with the maintenance and repairs, of this system will far exceed the first cost of properly designed shafting and belting plus maintenance and repairs (in most shops entirely too light belts and countershafts of inferior design are used, and the belts are not systematically cared for by one trained man, and this involves a heavy cost for maintenance). There is no question, therefore, that in many cases the motor drive means in the end additional complication and expense rather than simplicity and economy.

"It is at last admitted that there is little, if any, economy in power obtainable through promiscuous motor driving; and it will certainly be found to be a safe rule not to adapt an individual motor for driving any machine tool unless a clearly evident and large saving can be made by it.

Conclusion.

"In concluding let me say that we are now but on the threshold of the coming era of true co-operation. The time is fast going by for the great personal or individual achievement of any one man standing alone and without the help of those around him. And the time is coming when all great things will be done by the co-operation of many men, in which each man performs that function for which he is best suited, each man preserves his own individuality and is supreme in his particular function, and each man at the same time loses none of his originality and proper personal initiative, and yet is controlled by and must work harmoniously with many other men.

"And let me point out that the most important lessons taught by these experiments, particularly to the younger men, are:

"Several men when heartily co-operating, even if of everyday caliber, can accomplish what would be next to impossible for any one man even of exceptional ability.

"Expensive experiments can be successfully carried on by men without money, and the most difficult mathematical problems can be solved by very ordinary mathematicians, providing only that they are willing to pay the price in time, patience and hard work.

"The old adage is again made good, that all things come to him who waits, if only he works hard enough in the meantime."

Cars and Locomotives Ordered in 1906.—According to the *Railway Age*, there were 310,805 freight cars, 3,402 passenger cars and 5,642 locomotives ordered by the railroads of the United States, Canada and Mexico in 1906, as compared with 341,315, 3,289 and 6,265, respectively, in 1905. Deducting Canadian and Mexican orders from shops in the two countries and 28,810 cars ordered by railroads of the United States from their own shops, the number of freight cars ordered from contract shops in the United States in 1906 is found to be 258,866, as against 302,876 in 1905. A total of 142,172, or 46 per cent., of the freight cars ordered in 1906 were specified to be of steel or to have steel underframes. It is estimated that, while the contract shops had a capacity of 175,000 cars in 1905, the present capacity is 200,000 cars, and that of 1907 will be 250,000 cars. It is also estimated that two-thirds of the capacity for 1907 is engaged by the orders now in hand.

New Home of the A. S. M. E.—On January 1 the American Society of Mechanical Engineers removed its headquarters to the new Engineering Societies Building at 29 West Thirty-ninth street, New York City.

PACIFIC TYPE LOCOMOTIVES.

NATIONAL RAILWAY OF MEXICO.

The National Railway of Mexico has recently purchased six Pacific type passenger locomotives, which include an example of four different cylinder arrangements and of both Walschaert and Stephenson valve gear. Five of these were built by the American Locomotive Company, and consist of three simple engines, one Cole balanced compound, and one simple engine fitted with Alfree-Hubbell valves and cylinders. The sixth engine is a Baldwin four-cylinder balanced compound, built by the Baldwin Locomotive Works.

All of these locomotives are of practically the same design outside of the cylinder arrangement, and all have Stephenson valve gear except the Cole compound. The Baldwin engine differs from the others in several details, some of which will be referred to later. The simple engines carry 200 lbs. steam pressure and the compounds 220 lbs.

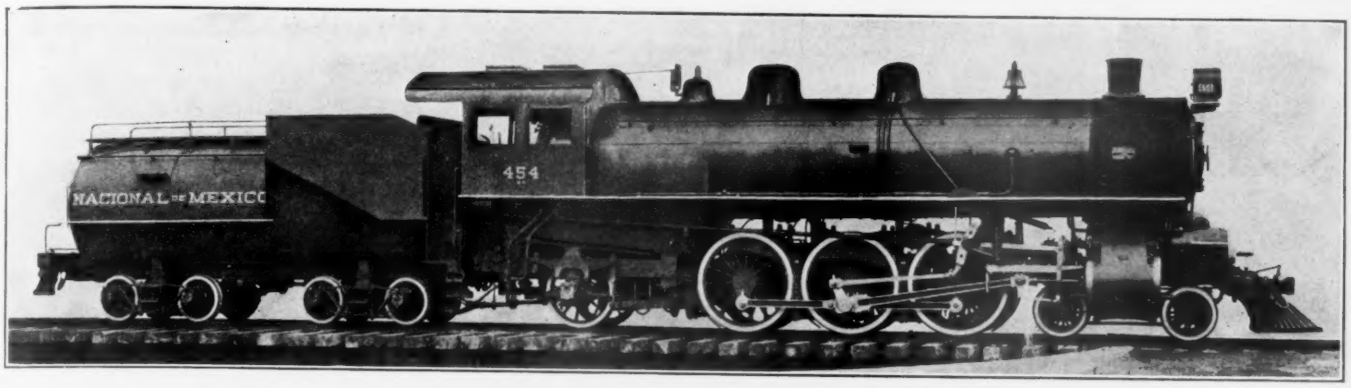
The three simple engines with Richardson slide valves weigh 222,500 lbs. total, of which 141,300 lbs. is on drivers, giving an average weight of 47,100 lbs. per axle on a rigid wheel base of 12 ft. 3 ins. This weight, for a wheel base of 12 ft., is exceeded by but one other simple high speed locomotive on our records, viz.: the Northern Pacific 4-6-2 type, which weighs 49,170 lbs. per axle. It, however, is often exceeded in other types of three coupled simple locomotives for moderately high speed work, as well as in balanced compounds of the 4-6-2 type. The wheels are 67 ins. diameter, and the cylinders have a diameter of 22 ins. and a 28-in. stroke, which gives a tractive effort of 34,400 lbs. at 85 per cent. boiler pressure. The factor of adhesion is 4.11.

The boilers are of the straight type, 74½ ins. in diameter at the front ring. They contain 306 2¼-in. tubes 20 ft. long, giving a tube heating surface of 3,588 sq. ft. The firebox heating surface of 210.3 sq. ft. is 5.55 per cent. of the total. The grate area of 51.6 sq. ft. gives 1 sq. ft. to every 73.2 sq. ft. of total actual heating surface and to 17.5 sq. ft. of equated heating surface. These ratios indicate that with a moderately good grade of coal there should be no difficulty in furnishing all the steam needed. The fireboxes are radially stayed and an unusually deep throat is provided.

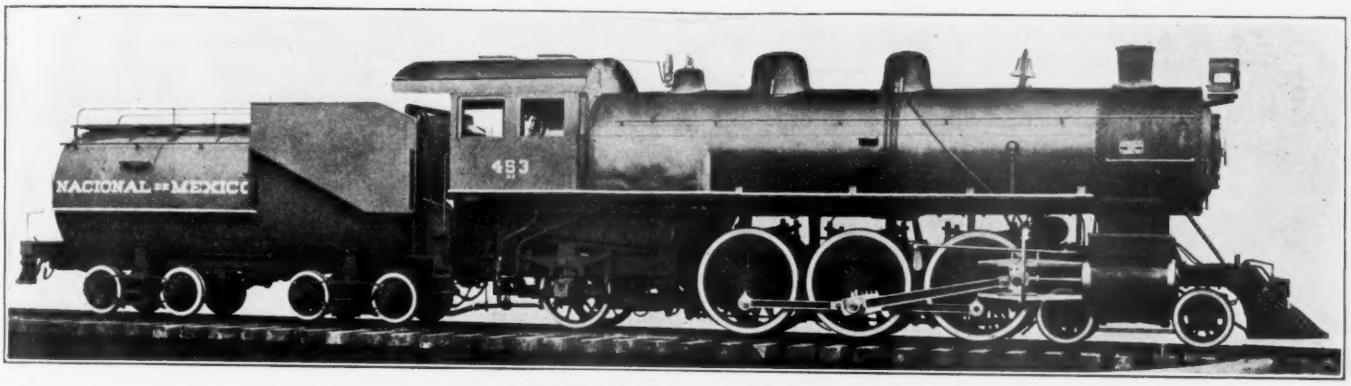
The accompanying table of dimensions will permit a comparison of the ratios and dimensions of these locomotives with one of approximately the same size and power recently built for the Chicago, Burlington & Quincy Railway.

The locomotive fitted with the Alfree-Hubbell valves and cylinders is not different in other respects from the one above considered. This arrangement of cylinders, as applied to a consolidation locomotive on the Chicago, Rock Island & Pacific Railway, has been thoroughly described and illustrated.* The principal features of this design are that it gives a delayed exhaust opening and closure for all points of cut-off, an increased exhaust area and a large reduction in cylinder clearance. In the present case with a cut-off at 6¾ ins., the exhaust opens at 21⅞ ins. and closes at 25¼ ins., giving but 2¾ ins. compression. This delayed exhaust closure permits the large reduction in cylinder clearance which has been accomplished. The reduction in this case is from 8 per cent. to 2½ per cent. of the stroke in the cylinder and over 70 per cent. of the port volume. In brief, the construction consists of a very long steam valve set at an angle of 15 degs., with the transverse horizontal and as close to the cylinder as possible, the top wall of the cylinder forming the valve seat. The cylinder ports are practically straight and give an opening on the valve seat equal to the diameter of the cylinder. The increased area for the exhaust and the delayed exhaust closure is obtained by means of a supplementary compression controlling valve which is operated from a dash pot connection on the main valve. It consists of piston valves about 5 ins. diameter equipped with wide special rings which fit openings

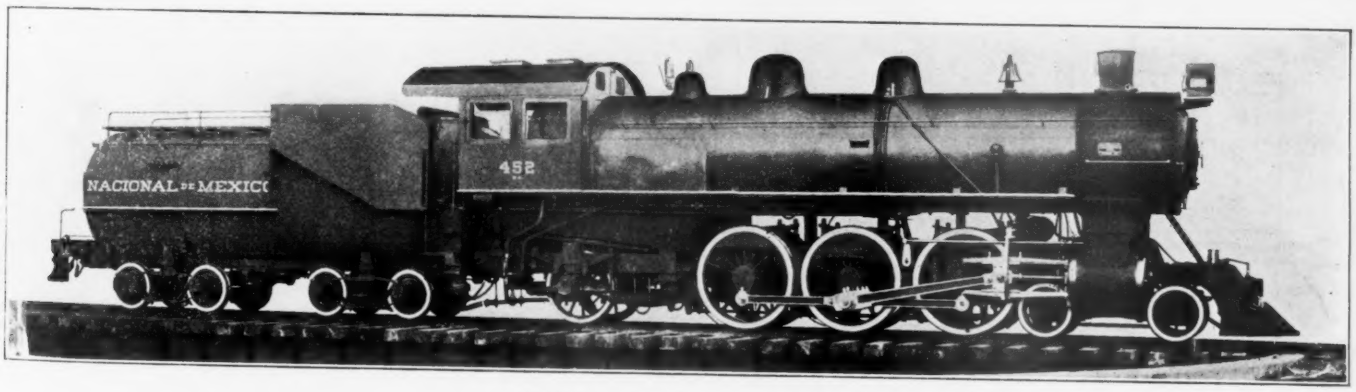
*See American Engineer, September, 1906, pp. 334.



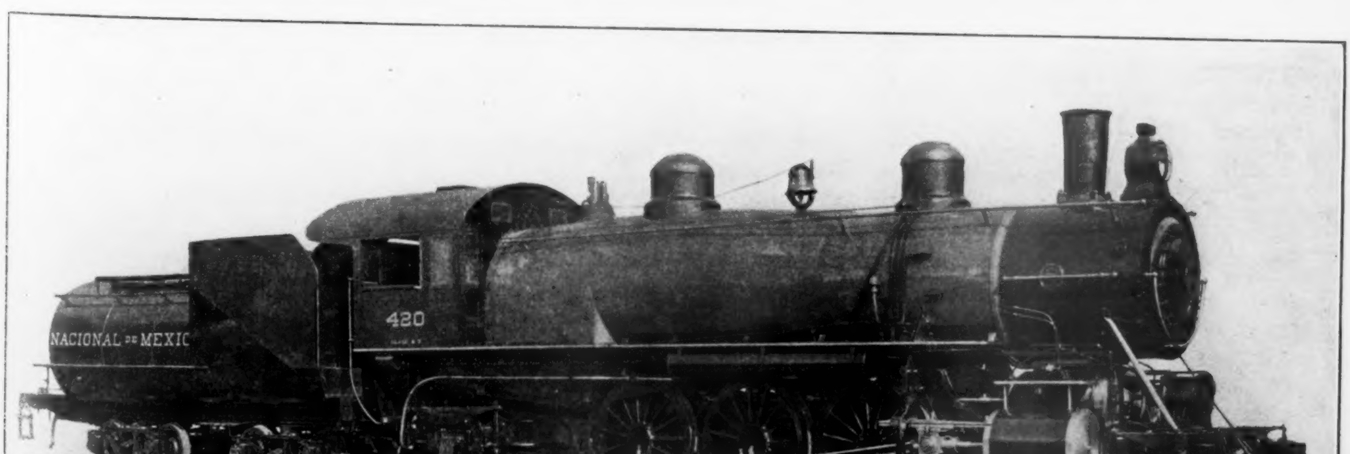
COLE BALANCED COMPOUND LOCOMOTIVE.



ALLFREE-HUBBELL TYPE LOCOMOTIVE.

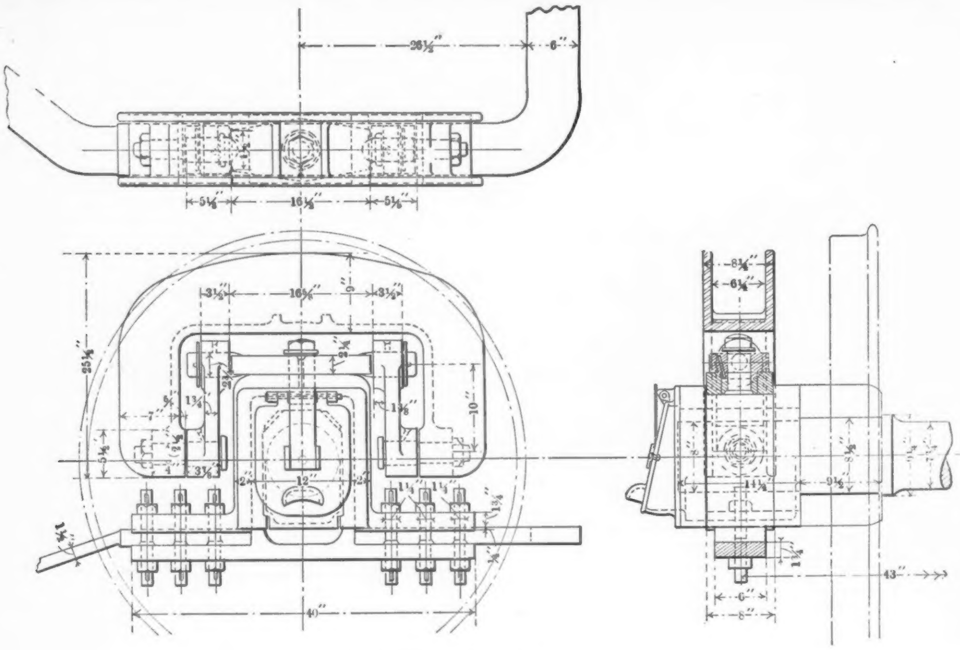


SIMPLE SLIDE VALVE LOCOMOTIVE.

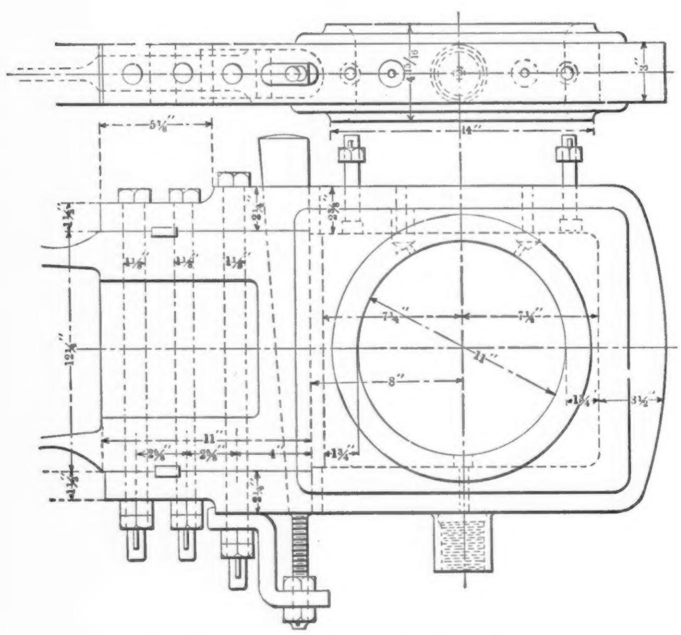


BALDWIN BALANCED COMPOUND LOCOMOTIVE.

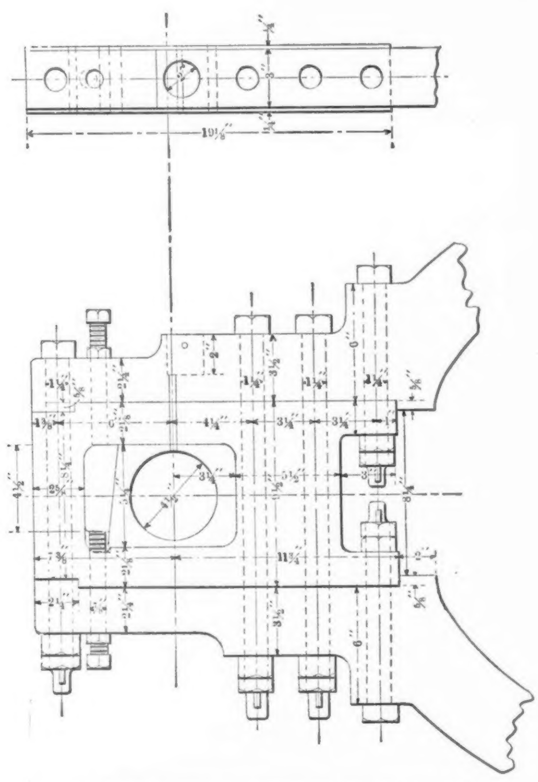
PACIFIC TYPE LOCOMOTIVES—MEXICAN NATIONAL RAILWAY.



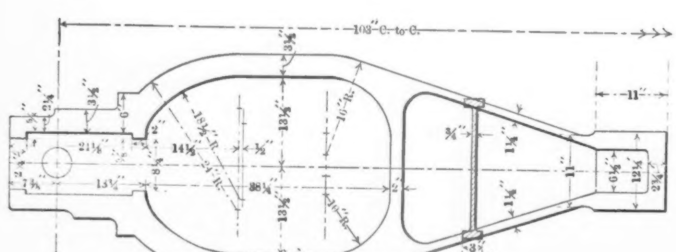
RUSHTON TRAILER TRUCK.



CRANK END OF BIFURCATED MAIN ROD.



CROSSHEAD END OF BIFURCATED MAIN ROD.



BIFURCATED MAIN ROD.

in the wall between the steam port and exhaust passage. These are so connected to the main valve that they open simultaneously with the opening of the exhaust edge of that valve, but do not close until it has moved 1¼ ins. beyond the point of exhaust closure. The area of these openings is 19 sq. ins., and is sufficient to hold down the back pressure line to very near the end of the stroke. The delayed exhaust opening is obtained by using a 7-16 in. exhaust lap on the main valve. The main steam valves are so designed that even in the shortest valve travel one portion of the valve laps the travel of another part on the valve seat, and thus produces a uniform wearing effect.

This design of valves and cylinders has now been in operation in both heavy freight and high speed passenger service for over a year on other roads with the most satisfactory results, both as regards economy of operation and maintenance, as well as in giving a very quick and responsive engine.

The Cole balanced compound in this order is the second application of this design to a Pacific type locomotive, the former being the one built for the Northern Pacific Railway. This engine was very completely illustrated and described in this journal in November, 1906, page 411, and since the Mexican National locomotive is practically a duplication of that design, as far as cylinders are concerned, reference can be made to that article for all details. This locomotive differs from the simple engines just mentioned, in the fact that the cylinders have been moved 12 ins. ahead and the forward pair of driving wheels 3 ins. back, thereby increasing the distance between the forward driving wheels and the center of the saddle by 15 ins. and lengthening the boiler by 12 ins., this increase being ahead of the front flue sheet. A noticeable difference is found in this design as compared with previous Cole compounds, in the fact that the high pressure cylinders have a stroke of but 26 ins., while the low pressure cylinders have a 28-in. stroke. This has been done for the purpose of making the angularity of the high and low pressure rods more nearly equal, and has also resulted in reducing the weight of the cranked axle. Reference to the accompanying table of dimensions will give a comparison between these two locomotives, as well as other balanced compounds, and in considering this table it should be remembered that the boiler of the Northern

Owner	Mex. Nat.	Mex. Nat.	C., B. & Q.	Mex. Nat.	A., T. & S. F.	Mex. Net.	N. P.
Kind of cylinders	Simple	Allfree-Hubble	Simple	Bald. Comp.	Bald. Comp.	Cole Comp.	Cole Comp.
Builder	American	American	Baldwin	Baldwin	Baldwin	American	American
Tractive effort, lbs	34,400	34,400	32,690	35,066	32,250	31,900	30,340
Weight in working order, lbs	222,500	223,500	230,940	227,340	226,700	241,000	240,000
Weight on drivers, lbs	141,300	142,000	151,290	147,040	151,900	150,000	157,000
Weight of engine and tender in working order, lbs	358,300	359,300	382,000	370,000	402,783	377,200	380,500
Wheel base, driving, ft. and ins	12-3	12-3	12-10	12-0	13-8	12-0	12-0
Wheel base, total, ft. and ins	33-0	33-0	32-9	33-11	34-0	34-0	33-5
Wheel base, engine and tender, ft. and ins	63-3¼	63-3¼	64-3¼	62-11	66-1½	64-3¼	62-10
RATIOS.							
Weight on drivers ÷ tractive effort	4.11	4.13	4.63	4.2	4.75	4.7	5.18
Total weight ÷ tractive effort	6.47	6.5	7.07	6.46	7.	7.55	7.9
Tractive effort x diam. drivers ÷ heating surface	610.	610.	615.	632.	655.	562.	720.
Total heating surface ÷ grate area	73.2	73.2	72.8	71.2	68.	73.5	67.
Firebox heating surface ÷ total heating surface (per cent.)	5.55	5.55	4.85	5.	5.38	5.55	8.3
Weight on drivers ÷ total heating surface	37.2	37.5	38.5	37.4	42.3	39.5	53.8
Total weight ÷ total heat. surface	58.7	58.9	59	61.1	63.1	63.5	82.5
Volume both cylinders, cu. ft	12.32	12.32	12.32	11.5	11.5	10.27	9.9
Total heating surface ÷ vol. cylinders	308	308.	318.	322.	312.	370.	294.
Grate area ÷ vol. cylinders	4.18	4.18	4.46	4.54	4.61	5.	4.3
CYLINDERS.							
Number	2	2	2	4	4	4	4
Diameter, ins.	22	22	22	17 & 28	17 & 28	16½ & 27	16½ & 27½
Stroke, ins.	28	28	28	28	28	26 & 28	26
VALVES.							
Kind	Bal. Slide	Bal. Slide	Piston	Piston	Piston	Piston	Piston
Diameter, in.	......	......	12	15	......	......	14
WHEELS.							
Driving, diameter over tires, in	67	67	74	67	73	67	69
Driving, thickness of tires, in	3½	3½	4	3⅓	3½	3½	3½
Driving journals, main, diam. and length, in.	10x12	10x12	9½x12	11x10	11x10	10x12	11x11⅓
Driving journals, others, diam. and length, in.	9x12	9x12	......	9x12	9x12	F 11x11¼-B 10x12	9½x12
Engine truck wheels, diam., in	33	33	37¼	30	31¼	33	33½
Engine truck, journals, in	6x12	6x12	6x12	6x10	6x10	6x12	6½x12
Trailing truck wheels, diam., in	50	50	48	48	43	50	45
Trailing truck, journals, in	8x14	8x14	8x12	8x14	7½x12	8x14	8x14
BOILER.							
Style	Str.	Str.	W. T.	W. T.	W. T.	Str.	E. W. T.
Working pressure, lbs	200	200	210	220	220	220	220
Outside diameter of first ring, in.	74½	74½	70	70	70	74⅝	72¼
Firebox, length and width, in	113⅛x65¼	113⅛x65¼	108⅛x72¼	113½x66¼	108x71¼	113⅛x65¼	96x65¼
Firebox plates, thickness, in	⅜ & ½	⅜ & ½	⅜ & ½	⅜ & ½	⅜ & ¼	⅜ & ½	⅜
Firebox, water space, in	F 4½-S & B 4	F 4½-S & B 4	F 4½-S & B 4	F 4½-S & B 4	F 4½-S 5-B 4	F 4½-S & B 4	F 4½-S & B 4
Tubes, number and outside diam., in.	306-2¼	306-2¼	303-2¼	301-2¼	290-2¼	306-2¼	306-2
Tubes, length, ft. and ins	20-0	20-0	21-0	20-0	20-0	20-0	16-9
Heating surface,, tubes, sq. ft	3588.	3588.	3732.	3527.	3402.2	3588.	2667.
Heating surface, firebox, sq. ft	210.3	210.3	190.	186.	192.8	210.3	241.8
Heating surface, total, sq. ft	3798.3	3798.3	3933.	3713.	3595.	3,798.3	2908.8
Grate area, sq. ft	51.6	51.6	54	52.1	53.	51.6	43.5
Smokestack, diameter, in	18	18	......	......	......	18	18
Smokestack, height above rail, in.	180	180	......	......	......	180	185½
Centre of boiler above rail, in	......	......	110	109	......	116	115
TENDER.							
Tank	Vanderbilt	Vanderbilt	Water Bot.	Vanderbilt	Water Bot.	Vanderbilt	Water Bot.
Frame	6"x4" Angles	6"x4" Angles	Steel	Steel	Steel	6x4 Angles	13" Chan.
Weight	135,800	135,800	151,060	142,660	176,083	136,200	140,500
Wheels, diameter, in	33	33	37¼	33	34¼	33	33½
Journals, diameter and length, in.	5½x10	5½x10	5½x10	5½x10	5¼x10	5½x10	5½x10
Water capacity, gals	7,500	7,500	8,000	7,500	8,500	7,500	7,000
Coal capacity, tons	12	12	16	12	3,300 G	12	12
Reference in the AMERICAN ENGINEER			8-06, p 302		12-05, p 454		11-06, p 411

Pacific locomotive has a combustion chamber, which largely reduces its actual total heating surface.

The Baldwin balanced compound locomotive differs from the others outside of the cylinder and its connection principally in the fact that it has an extended wagon top boiler and that Stephenson valve gear with eccentrics on the third axle and a very long valve rod is provided. The boiler, although of smaller diameter in front, is of practically the same capacity, having but five less flues and a slightly smaller firebox heating surface. The valve rod, which extends along the top of the frame, is supported at two intermediate points and is provided with a knuckle joint about 5 ft. ahead of the rocker arm, the total distance from the rocker arm to the valve chamber being about 15 ft. The frame centers are 44 ins. apart except for a short distance at the main driving wheels, where it has been increased to 45½ ins. in order to secure a main driving journal 10 ins. long between the cheek of the cranked axle and the face of the wheel hub.

This locomotive is very similar to one built in 1905 for the Atchison, Topeka & Santa Fe Railway. The cranked axle is on the second pair of drivers, and the main rod from the high pressure cylinders is of a bifurcated design spanning the front axle. A difference is noticed in this later design of main rod, as will be seen in the illustration, in the fact that the front end of the rod is provided with lips which bear against the body of the stub, thus relieving the stub bolts of the large shearing stress which necessarily accompanies the starting and stopping of a heavy rod of this design. The front brass is split and is provided with a wedge adjustment. The back stub is fitted with the usual strap and key. Reference can be made to the description of the Santa Fe locomotive mentioned for an illustration of the previous design of this rod. The crank axle is built up of 7 pieces of a design recently illustrated in connection with the balanced compound Prairie type for the Santa Fe.

The trailing truck of this locomotive is of the Rushton type, it, however, in this case being arranged for outside journals. As can be seen in the illustration, the box is held rigidly between the pedestals and the cast steel equalizer or spring seat is suspended directly on the swing links. The bearings for the swing links are bolted to a supplementary frame, which is secured to the main frame by means of cast steel brackets.

The tenders of all of these locomotives are of the Vanderbilt type with a capacity of 7,500 gals. of water and 12 tons of coal.

This order of locomotives, which includes four different cylinder arrangements on locomotives practically identical in other respects, gives the National Railways of Mexico an exceptional opportunity to try out these features, and develop

their possibilities in actual service under the conditions found on its railways.

Baldwin Balanced Compound Locomotives have been illustrated and described in this journal as follows: Plant System, 4-6-0, March, 1902, page 72. A. T. & S. F. Ry., 4-4-2, June, 1903, page 212. C. B. & Q., 4-4-2, June, 1904, page 211. N. Y., N. H. & H., 4-6-0, December, 1904, page 466. C. & E. I. Ry., 4-6-0, March, 1905, page 97. N. Y. C. & H. R. R. R., 4-4-2, April, 1905, page 109. Erie R. R., 4-4-2, May, 1905, page 177. O. R. & N., 4-6-2, July, 1905, page 246. C. R. I. & P., 4-4-2, November, 1905, page 416. A. T. & S. F., 4-6-2, December, 1905, page 455. A. T. & S. F., 2-6-2, November and December, 1906, pages 434 and 481. U. P. R. R., 4-4-2, August, 1906, page 308. N. C. & St. L. Ry., 4-6-0, February, 1906, page 69. P. R. R., 4-4-2, February, 1906, page 70.

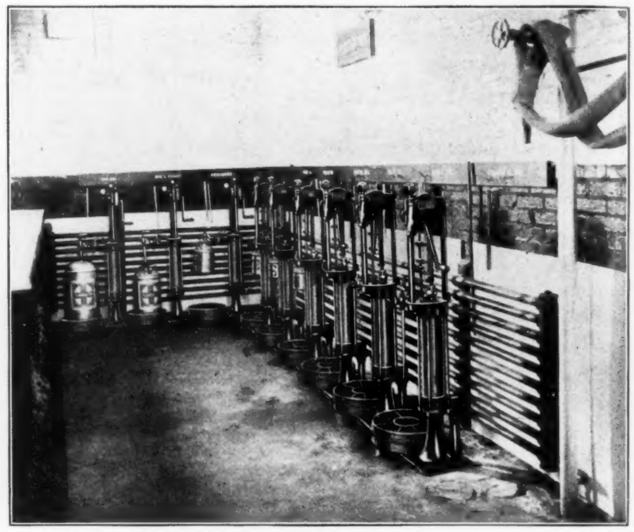
Cole Balanced Compound Locomotives have been illustrated and described in this journal as follows: N. Y. C. & H. R. R. R., 4-4-2, May and June, 1904, pages 166 and 240. Erie R. R., 4-4-2, August, 1905, page 287. P. R. R., 4-4-2, February, 1906, page 70. N. P. Ry., 4-6-2, November, 1906, page 411.

Inefficient Transportation Facilities.—To many witnesses at both Minneapolis and Chicago it was obvious that if cars were made to move faster and were kept moving, their efficiency would be greatly increased. Car shortage, in other words, may result as much from lack of wise methods in handling the cars which a company possesses as from a deficiency in the number of cars or a lack of tractive power. If engines are made to haul their maximum, it is manifest that their capacity is limited to the highest grade over which they are compelled to pass. If trains are made up of so large a number of loaded cars that the engine is reduced to its minimum speed, these cars during their time of transit are withdrawn from the general car supply. From the statistics presented it would appear that the policy of hauling maximum loads on long hauls is one that produces dazzling figures of ton mileage which should greatly gratify the railroad stockholder did not the troublesome problem arise of the carrier's duty to render prompt service and make the fullest possible use of the railway and its facilities. Maximum tonnage and maximum service are not necessarily equivalents. A railroad which lives by virtue of a public grant and the exercise of quasi-public powers is primarily obligated to discharge its functions with an eye to the welfare of the public which it serves and to avoid any policy of operation which, no matter how profitable to the stockholder, may result injuriously to its dependent communities.—*Interstate Commerce Commission Investigation.*

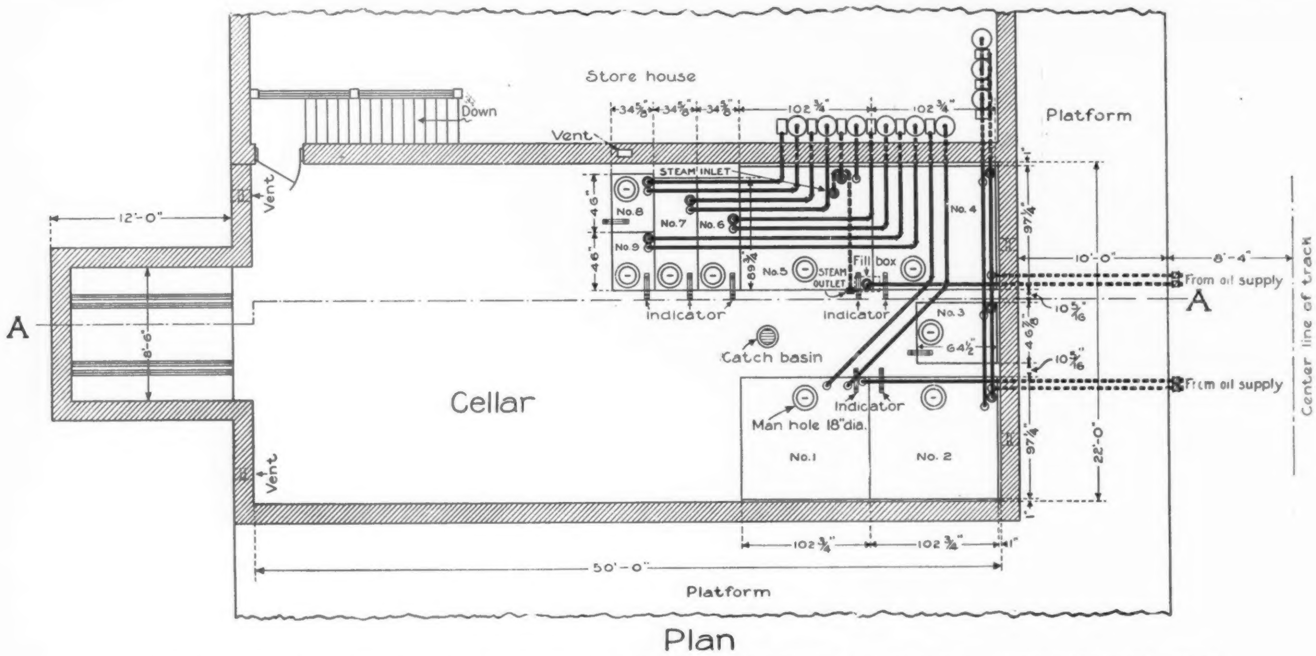
Opportunity for talent at this time is unlimited. From an organization and economical standpoint, generally speaking, the actual operation of railroads is in its infancy. We have, indeed, hardly begun.—*Mr. D. T. Taylor, St. Louis Ry. Club.*

OIL STORAGE ON THE SANTA FE.

Railroads everywhere are confronted with the serious problem of how to store and handle the various oils which are used. To keep the oil in barrels and drums entails considerable loss from leakage, waste, evaporation and seepage. Gravity systems have been tried and found unsatisfactory—very little better than the barrel storage method. Faucet tanks are at best unsightly, and the losses they allow total a considerable sum in a very short time. Then, too, aside from



CORNER OF STOREHOUSE SHOWING THE SELF-MEASURING PUMPS WHICH ARE CONNECTED WITH TANKS IN THE BASEMENT.



FIRST FLOOR PLAN OF OIL STORAGE SECTION OF SANTA FE STOREHOUSE AT SHOPTON (FORT MADISON), IOWA.

the actual oil loss, these methods are unsafe—they increase the fire risk because of the oil-soaked floors, leaking, overflowing oil and vapor-laden atmosphere, for which they are responsible.

The equipment recently installed in the storehouse of the Atchison, Topeka & Santa Fe Railway at Fort Madison, Iowa, by S. F. Bowser & Co., Inc., Fort Wayne, Ind., has solved for this railroad the various problems with which they have been confronted, and as similar equipments have been installed at other points along the Santa Fe System and also in the storehouses of a score of other railroads, a brief description of the Fort Madison installation may be of interest.

All of the oils are stored in tanks of the desired capacity located in the basement of the storehouse. The oils so handled and the capacities of the tanks are as follows:

No. 1.	3,000 gals.	engine oil.
No. 2.	3,000 gals.	kerosene oil.
No. 3.	600 gals.	special coach.
No. 4.	3,000 gals.	car oil.
No. 5.	3,000 gals.	valve oil.
No. 6.	600 gals.	mineral seal.
No. 7.	600 gals.	signal.
No. 8.	300 gals.	common black.
No. 9.	300 gals.	turpentine.

By referring to the plan drawing, the location of the tanks, designated by the above numbers, may be readily ascertained.

On the storeroom floor at the point most convenient for disbursing the oils are located nine long-distance, self-measuring pumps. These pumps are so designed that any kind of oil can be drawn from the tank to any part of the building. They are self-measuring; that is, a full stroke delivers an accurate gallon, while at the option of the operator they may be quickly adjusted to deliver a pint, a quart or a half-gallon at a stroke, as desired. The oil is, therefore, drawn and measured, at one operation, directly into the can to be filled without using funnels or measures.

The pumps are furnished with gallon meters, which keep an accurate record of all oil pumped; with discharge registers, which record the number of gallons pumped at each operation, and so prevent pumping more oil than was intended; with anti-drip nozzles, which shut off the flow of oil the instant pumping ceases; with self-locking devices, so that only authorized employes provided with keys can draw oil. The tanks are all vented to the outside of the building, thus providing an exit for excess gases; with manholes, making the tanks readily accessible for cleaning, etc., and with storage indicators, showing the amount of oil remaining in each tank and serving as a check on the delivery.

To provide for replenishing the tanks, each is equipped with a fill pipe running to the outside of the storehouse, so that they may be filled directly from the supply car on the tracks or from barrels on the outside platform.

This system of oil storage and control insures against all oil losses. It reduces to a minimum the time and labor involved in handling the oils, and removes all risk of fire. With it the oil room may easily be kept clean. As the oils are kept in an air-tight tank, and are not exposed to the air at any time, no dust, dirt or grit can become mixed with the oil and it is always kept clean and pure.

SHOE AND WEDGE CHUCK.

The shoe and wedge chuck, shown in Fig. 1, was designed by Mr. D. T. Rice, formerly with the Wabash Railroad. Not only does it make possible a saving in the time of setting the castings on the machine, but there is also a considerable saving in the time of machining, due to the use of the special tool shown in Fig. 3. The shoes and wedges are held in place

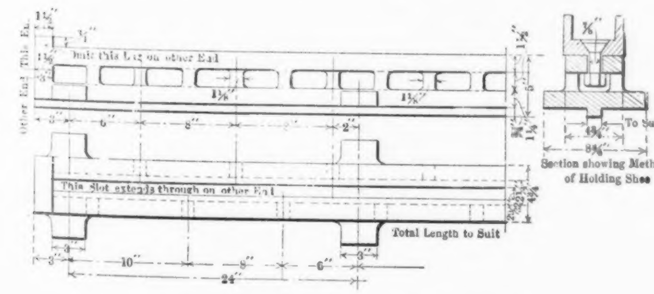


FIG. 1.—SHOE AND WEDGE CHUCK.

by taper head bolts, as shown. The holes are cored by green sand cores, and no drilling or chipping need be done before the castings are taken to the planer.

Butting the castings end to end, the chuck is filled and the nuts on the taper bolts are tightened by a wrench working between the ribs of the chuck. The tool shown in Fig. 3 is then used for taking a roughing and finishing cut down the inner sides of the flanges. The tools may readily be adjusted for various widths of frame fits. The bottom surface is finished with an ordinary tool, after which both outside surfaces of the flanges are finished at the same time by using two planer heads. The castings are then ready to be fitted by the erecting gang.

The installation of this device was instrumental in saving two-thirds of the time required for setting the shoes and wedges by old methods and in reducing the time of machining approximately one-half. The same chuck could, of course, be used to advantage on a milling machine.

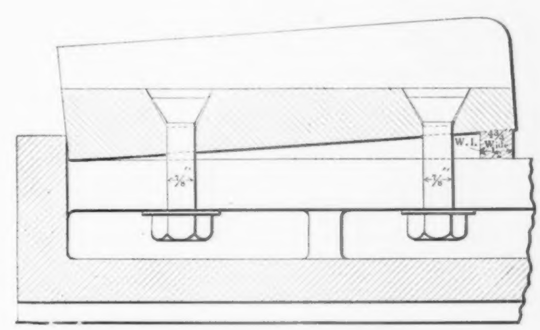


FIG. 2.—METHOD OF HOLDING SHOE.

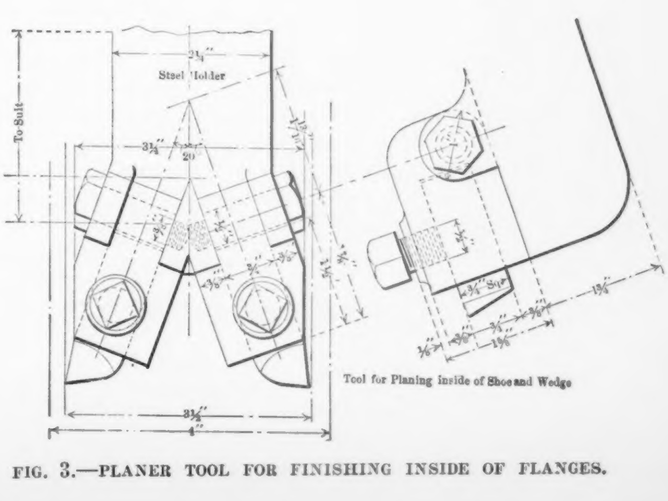
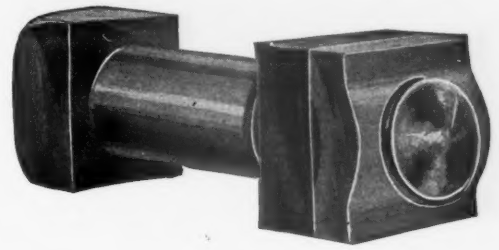


FIG. 3.—PLANER TOOL FOR FINISHING INSIDE OF FLANGES.

A NEW LOCK NUT.

A lock nut, known as the "Grip Nut," has recently been placed on the market, which combines the following desirable qualities: It may be placed in any position on the bolt; may be tightened any portion of a turn or several turns when necessary, and is durable, simple and inexpensive. It is a one-piece steel nut, made from bars rolled with an arch or



"GRIP NUT."

bow along the center. The nut is punched, cut off and tapped in the usual manner, after which the operation is performed which makes it so effective as a lock nut. This consists in running the nuts through a deflecting press which depresses the threads in the arch at each end, or in other words, the arch threads are straightened as compared to the true spiral of the original thread. These deflected threads grip the bolt in a friction lock which cannot be loosened by vibration.

The nuts may readily be removed with a wrench and can be used many times.

It is not necessary to jam the "Grip Nut" against the first nut, as it does not depend upon the friction of contact with the first nut for its holding power, but locks itself upon the threads of the bolt because of its slightly deflected threads. It therefore cannot be classed as a jam or a split nut, and does not require spring lock washers, cotter pins, keys and other similar devices. It requires no change in the standard bolt. The nuts have been tested in severe service, in both frog, crossing and car truck work, for three years, and are said to have fully demonstrated their value and effectiveness for work of this kind.

R. W. Hunt & Co. recently tested these nuts for strength and efficiency, and also determined the frictional resistance of the different sizes from ⅝ in. to 1 in., inclusive. The smaller size "Grip Nuts" were found to be as strong as the bolt, while the 1-in. nuts were 65 per cent. as strong as the bolts, the tensile strength of the bolt material being taken at 65,000 lbs. per square inch. In a test of the frictional resistance on a 1-in. track bolt when screwed on until the bearing face of the nut was 1¼ ins. from the end of the bolt, the pull necessary to unscrew the nut with a wrench having a radius of 18 ins. was 34 lbs. and the turning moment 612 in. lbs. The pull necessary to unscrew the nut when force was applied at its corner was 583 lbs., and that necessary at the thread 1,224 lbs.

At present these nuts are being used extensively on electric railway tracks and equipment, especially on high speed interurban roads. These nuts are made by the Grip Nut Company, with offices at 152 Lake street, Chicago, and 500 Fifth avenue, New York. A new mill has recently been completed, which has a capacity for nearly 200,000 of these nuts per day, but it is expected that this will have to be enlarged in the near future.

VARIABLE SPEED PLANER.

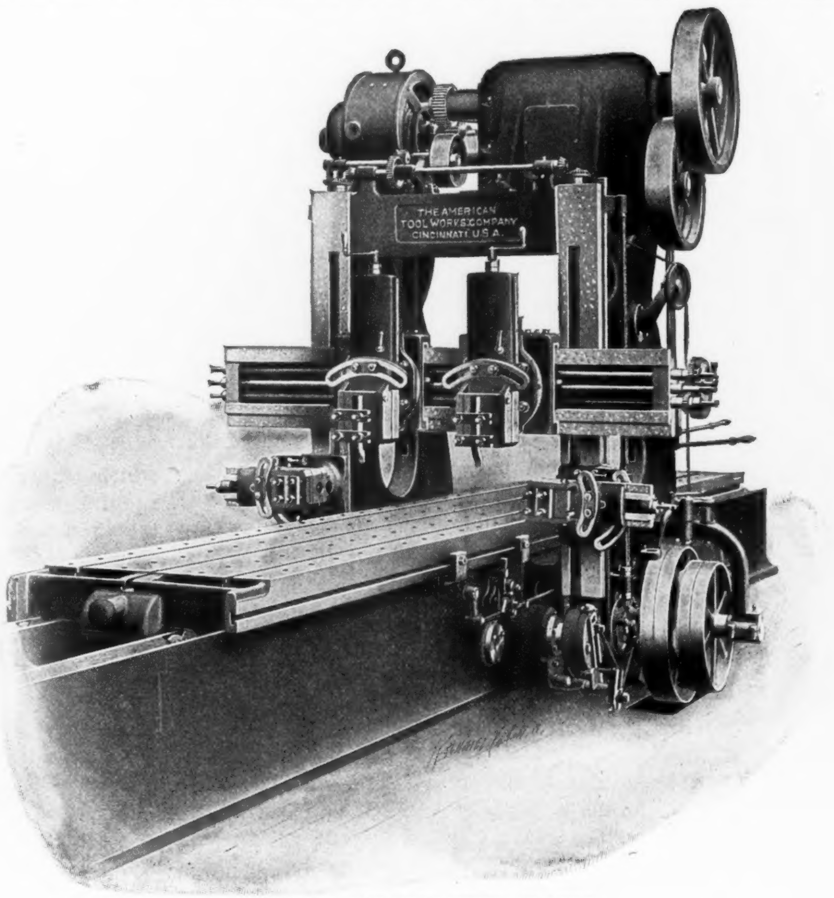
To meet the demand for variable speed planers for certain classes of work, with the resultant increase in output, the American Tool Works Company, of Cincinnati, has developed two lines of variable speed planers, one furnishing four different cutting speeds with a constant return speed, and the other two cutting speeds with a constant return speed.

Any one of the cutting speeds on the planer furnishing four cutting speeds may quickly be obtained by means of two levers, conveniently placed. An index plate shows how to obtain the desired speed. The different speeds are furnished by a speed box, and an interlocking device is provided to prevent engaging two conflicting speeds at the same time. The speed box has been carefully designed with a view to efficiency, durability and simplicity, and the speeds have been carefully selected to meet the requirements of up-to-date planer practice. The platen has a constant high speed return, and this, in conjunction with the variable cutting speeds, makes it possible to attain a high degree of efficiency, especially in cases where it is necessary to do a variety of work on the same planer.

The speed box is bolted to the top of the housings, which are especially designed to furnish it a substantial support. The speed box gears run in oil, the box being entirely enclosed, thus reducing the noise to a minimum, insuring economy of oil consumption and freedom from flying oil. The gears are of ample proportions, with wide faces and coarse pitch. The pinions are of steel, cut intregal with the shafts. Special cutters are used for cutting the gears to insure accuracy, long life and minimum noise. All shafts in the speed box run in long bronze bushed bearings, provided with ring oilers. No friction clutches or drives are used.

The driving pulleys have flywheel rims, reducing shocks to the driving mechanism, due to reversal, to a minimum and furnishing a steady, even pull at the cutting tool. The careful design of the driving mechanism and planer details makes it possible to turn out a high grade and accurate class of work.

The planers are furnished with either a belt or motor drive. If on the motor driven machine the motor should get out of order, the driving pinion on the outside of the speed box may be replaced by a pulley and the planer be driven by the belt from a countershaft or another motor conveniently placed. The flexibility of this construction insures the constant use of the machine at all times. The belt driven planer may



AMERICAN VARIABLE SPEED PLANER.

readily be equipped with a motor drive at any time after installation.

The planers equipped for two cutting speeds with a constant return speed are driven from a simple two-speed countershaft, which is self-oiling, thus requiring a minimum amount of attention.

THE PENNSYLVANIA RAILROAD LOCOMOTIVE TESTING PLANT.

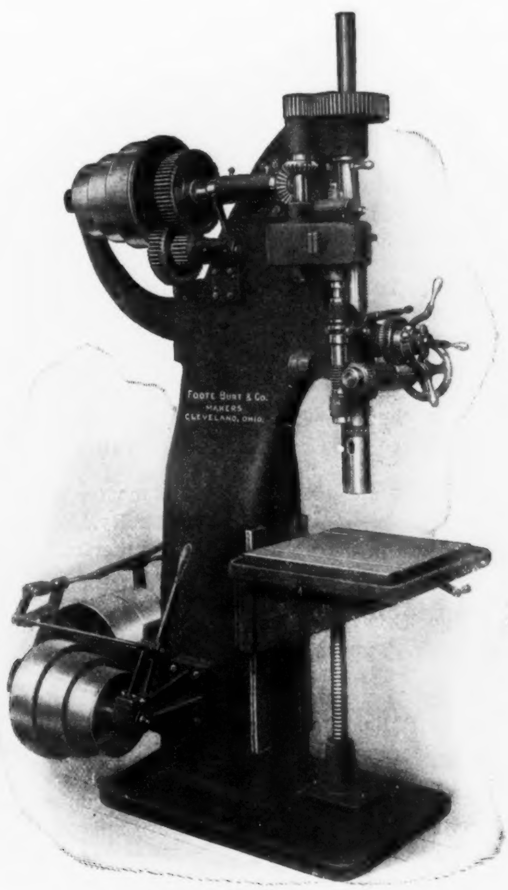
The locomotive testing plant of the Pennsylvania Railroad has been installed and is now in operation in a specially designed building at Altoona, Pa. The original program of tests, which it was impossible to complete at St. Louis, is being continued, and at present a Pennsylvania class E-3-A, which is a 20½ x 26-in. simple Atlantic type locomotive, with slide valves, Stephenson valve gear and Belpaire boiler carrying 205 lbs. pressure, is being tested. It will be remembered that all the passenger locomotives tested at St. Louis were of the four-cylinder balanced compound design, and it is expected that the results from a simple locomotive of the same type will be of much value for comparison. It is proposed to follow this locomotive with one of the class E-3-B, which is

of the same design in all respects, except that it has Walschaert valve gear and piston valves.

These tests are being carried on with the same grade of coal and with all the influencing conditions, as far as possible, the same as at St. Louis.

HIGH DUTY VERTICAL DRILL.

The use of high speed steel drills has made it necessary to radically change the design of vertical drills. The illustration shows a recent design of Foote, Burt & Co., which is guaranteed to drive high speed drills, up to and including 2¼ ins.



FOOTE-BURT HIGH DUTY DRILL.

in diameter, to the limit of their capacity. The design of the column, the method of attaching and supporting the table, and the size and arrangement of the spindle are such that under the above conditions there is no deflection between the point of the drill and the table, thus allowing the drills to be operated economically and eliminating danger of breakage due to the drill "catching."

The drills may be furnished either with or without the back gear and the right angle drive, as shown. They are built in two sizes, 24 and 36-in. swing. The leading dimensions are as follows:

Maximum distance nose of spindle to top of table.............32 ins.
Distance from center of spindle to face of column.........12 or 18 ins.
Power feed to spindle..16 ins.
Size of spindle in sleeve....................................2¼ ins.
Three changes of geared feed for each spindle speed,
.007 in., .016 in., .033 in.
Spindle feed rack of steel ....1¾-in. face
Size of table inside of oil pockets...........20x20 ins., with 2 T slots
Ratio of back gearing ....3½ to 1
Weight ....2,680 lbs.

The spindle is of forged high carbon steel. The sleeve is 23 ins. long. Ball-bearing thrust collars of the Foote-Burt design are provided, using balls ⅝ in. in diameter. These are guaranteed to work satisfactorily under the most severe service without breakage of balls or crushing out of the collars.

Three changes of geared feed are provided, any one of which is instantly available by shifting a lever conveniently located. The hand worm feed, automatic stop and quick return levers are all within convenient reaching distance of the operator. The table is fitted to the column by a square locked slide and is clamped by straps. It is also supported underneath by a 2-in. square thread screw, which acts as a solid jack and at the same time elevates the table.

THE CHICAGO MIDGET ROTARY DRILL.

A rather unique and novel but useful air drill having a capacity for drilling up to 3-16 in. in steel and known as the "Midget Drill" has been placed upon the market by the Chicago Pneumatic Tool Company. The illustration compares it in size to a man's hand. It weighs complete only 2½ lbs.; the distance from the breast plate to the end of the spindle is 7⅝ ins.; from the center of the spindle to the outside of the housing, 1 in.; the motor speed is 22,000 r.p.m., and the

CHICAGO MIDGET PNEUMATIC DRILL.

spindle speed, 2,000 r.p.m. It is of the rotary type and is adapted for drilling tell-tale holes in staybolts or general light work where accuracy is required.

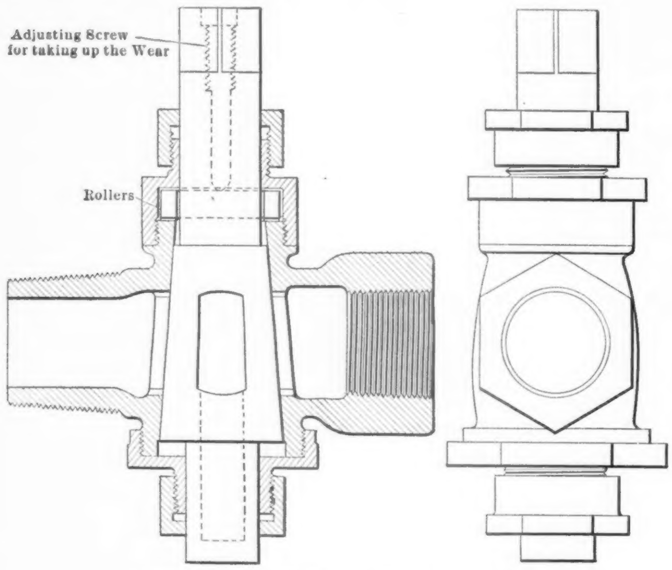
BALDWIN LOCOMOTIVE WORKS OUTPUT.—The number of locomotives built at the Baldwin Locomotive Works during the year 1906 was 2,652, of which 201 were electric and 2,451 steam; 281 locomotives were exported, the remainder being for domestic service. Of the 2,451 steam locomotives, 133 were equipped with compound cylinders. This is the largest output ever attained at these works, the figures for the three previous years being 2,022, 1,485 and 2,250, respectively. The number of men now employed at these works, exclusive of the Standard Steel Works, is about 19,000, and the number of working days last year was 307. Mr. George Burnham, Jr., retired from the partnership on Dec. 31, 1906.

THE GREATER SAFETY OF ALCOHOL as compared with gasoline for commercial uses is due to the fact that it will not ignite from pure radiated heat as gasoline does; that water will extinguish burning alcohol while it will only spread a fire of gasoline, and that the flame of burning alcohol radiates very little heat while that of gasoline radiates heat very rapidly.

AUTOMATIC STOKERS.—It is difficult to obtain firemen who can stand the very severe labor connected with the very large passenger and freight engines. An automatic stoker is absolutely necessary to enable the railroads to secure a better grade of men for the position of fireman.—*A B. & A. Official, in Railroad Men.*

ANDERSON LOCOMOTIVE BLOW-OFF COCK.

The Anderson blow-off cock, illustrated herewith, has several valuable and unique features. The plug is balanced and held in place by a patented roller locking device. This device consists of a rectangular piece of steel, which passes through the stem of the valve, and has journals at each end for the two rollers shown in the illustration. These rollers



ANDERSON LOCOMOTIVE BLOW-OFF COCK.

travel on incline planes, so that the valve is forced firmly to its seat when in a closed or open position. The adjusting screw takes up all wear. The valve can instantly be locked in neither an open or closed position. These features not only make the blow-off cock more satisfactory in operating, but add to its durability. They are manufactured by the Golden Anderson Valve Specialty Company, Pittsburgh, Pa.

INITIATIVE NECESSARY FOR SUCCESS.—A powerful initiative is inseparable from business ability. To conduct a railroad requires the same business attributes, from the stockholders' president to the gang boss, and no less, as to keep affoat a colossal industry on its by-products. The forceful men who have mastered these attributes find remunerative positions on every hand, ready to step into.—*Paul R. Brooks, before the New York Railroad Club.*

PERSONALS.

Mr. A. R. Ayers has been appointed supt. of shops of the L. S. & M. S. Ry. at Elkhart, Ind.

Mr. R. H. Rutherford has been appointed master mechanic of the Torreon division of the Mex. Cent. Ry.

Mr. M. Wesley Burke has been appointed general foreman of the Baltimore & Ohio R. R. at Garrett, Ind.

Mr. G. R. Ingersoll has been appointed purchasing agent of the L. S. & M. S. Ry., with headquarters at Cleveland, O.

Mr. J. T. Carroll has been appointed asst. supt. of shops of the L. S. & M. S. Ry. at Collinwood, O., vice Mr. R. D. Fildes, resigned.

Mr. J. W. Marden has been appointed supt. of the car department of the Boston & Maine R. R., with office in the Union Station, Boston.

Mr. Amenzo M. Carroll has been appointed asst. master mechanic of the Mohawk division of the N. Y. C. & H. R. R. R. at West Albany, N. Y.

Mr. Charles A. Bingham has been appointed engineer of tests of the P. & R. Ry., with office at Reading, Pa.

Mr. W. E. Chester has resigned as general master mechanic of the Central of Georgia Ry. The position is abolished.

Mr. F. R. Cooper, formerly master mechanic of the Lehigh Valley R. R., has been appointed supt. of motive power of the South Buffalo Ry.

Mr. W. J. Haynen has been appointed supt. of shops of the Pere Marquette, with office at Grand Rapids, Mich., succeeding Mr. M. C. Gregory, resigned.

Mr. A. H. Gairns has been appointed master mechanic of the first division of the D. & R. G. R. R., with headquarters at Burnham shops, Denver, Col.

Mr. Edward Payson Bullard, president of the Bullard Machine Tool Company, Bridgeport, Conn., died in Braidentown, Fla., December 22, aged 65 years.

Mr. R. F. Jaynes, genl. shop foreman, has been appointed to the new office of master mechanic of the Lehigh & Hudson River Ry., with office at Warwick, N. Y.

Mr. Thomas B. Purves, Jr., has been appointed supt. of motive power of the Denver & Rio Grande Ry., with headquarters at Denver, Col., succeeding Mr. J. R. Groves.

Mr. George W. Wildin has resigned as superintendent of motive power of the Erie R. R., and accepted the position of asst. supt. of motive power of the Lehigh Valley R. R.

Mr. J. M. Fulton has been appointed master mechanic of the Chihuahua division of the Mex. Cent. Ry., with office at Chihuahua, Mex., succeeding Mr. R. H. Rutherford.

Mr. C. D. Pettis has resigned as supervisor of the car department of the 'Frisco to become connected with one of the enterprises of Mr. Charles M. Hewitt, of Chicago.

Mr. George Moll, heretofore road foreman of engines of the P. & R. Ry. at Phila., Pa., has been appointed master mechanic of the Reading and Harrisburg divisions.

Mr. Thomas J. Tonge has been appointed supt. of motive power and rolling stock, bridges, building and water service of the Santa Fe Central, with office at Estancia, N. M.

Mr. J. E. Cameron, heretofore master mechanic of the Atlanta, Birmingham & Atlantic R. R., has been appointed supt. of motive power, with headquarters at Waycross, Ga.

Mr. E. O. Shivély, asst. div. master mechanic of the Wabash R. R. at Decatur, Ill., has been appointed genl. foreman of locomotives, and the former position has been abolished.

Mr. G. C. Gardner, heretofore asst. master mechanic of the P. R. R. at Trenton, N. J., has been appointed genl. foreman of all roundhouses and shops on the Belvidere division.

Mr. C. H. Wiggin has been appointed supt. of motive power of the Boston & Maine R. R. and will have charge of all motive power on the road, with office at Union Station, Boston.

Mr. Martin Bylander has been appointed acting genl. shop demonstrator of the U. P. R. R., with headquarters at Omaha, Neb., succeeding Mr. F. M. Titus, assigned to other duties.

Mr. John McGie, master mechanic of the C., R. I. & P. Ry. at Shawnee, Okla., has been appointed master mechanic of the Arkansas and Louisiana divisions, with office at Little Rock, Ark.

Mr. Albert McCready has been appointed road foreman of engines of the first and second districts of the Albuquerque division of the A., T. & S. F. (Coast Lines), vice Mr. James Englehart, resigned.

Mr. D. D. Briggs has been appointed master mechanic of the L. & N. R. R. at Montgomery, Ala., in place of Mr. Gifford.

Mr. C. Gifford has been appointed master mechanic of the L. & N. R. R. at Mobile, Ala., succeeding Mr. H. M. Minto.

Mr. E. T. James, who recently resigned as shop superintendent of the Lehigh Valley R. R., has been appointed master mechanic of the New York, New Haven & Hartford Ry., with office at New Haven, Conn.

Mr. Henry Bartlett has been appointed genl. supt. of the mechanical department of the Boston & Maine R. R. and will have charge of all of the company's rolling stock and its mechanical department, with office at Union Station, Boston.

Mr. C. M. Taylor, who recently resigned as mechl. supt. of the Western Grand division of the A., T. & S. F. Ry., has been appointed master mechanic of the Panhandle division of the C., R. I. & P. Ry. at Shawnee, Okla., succeeding Mr. McGie.

Mr. J. W. Small, heretofore master mechanic of the S. P. R. R. at Los Angeles, Cal., has been appointed supt. of motive power of the Arizona Eastern, the Arizona & Colorado, the Cananea Yaqui River & Pacific, the Maricopa & Phoenix & Salt River Valley and the Gila Valley Globe & Northern, with headquarters at Tucson, Ariz.

Mr. W. H. Hudson has resigned as general master mechanic of the Southern Ry. at Knoxville, Tenn., to accept the position of vice-president of the Georgia Locomotive Company, of Atlanta, Ga. Mr. Hudson has been connected with the Southern Ry. and its predecessor, the East Tennessee, Virginia & Georgia, almost continuously since 1882, when he began as a machinist.

Mr. F. H. Greene, heretofore purchasing agent of the L. S. & M. S. Ry., has been appointed general purchasing agent of all the New York Central lines, with headquarters at New York. Mr. Greene entered railway service in the year 1885 as clerk in the purchasing department of the Grand Trunk Railway, since which he has been consecutively to July, 1899, chief clerk of the general stores department of the Chicago & Northwestern, secretary to the supt. of motive power of the same road and traveling auditor, in charge of mail and supplies of the same road. In July, 1899, he went to the L. S. & M. S. Ry. as secretary to the supt. of motive power, and has been purchasing agent of that road and the Lake Erie & Western since Jan. 1, 1900.

Mr. John T. Chamberlain has resigned as master car builder of the Boston & Maine Railroad after many years of faithful service. Mr. Chamberlain is a native of Eckington, England, and was born May 21, 1849. He was educated in New York and began his railway career as an apprentice in the car shops of the Atlantic & Great Western R. R. in 1868. In 1870 he entered the service of the Boston & Albany at Allston, Mass., where he finished serving his time. He was foreman of the freight erecting and repair shops of that road in 1878, and from 1885 to 1888 was general foreman of the Allston shops. In 1888 he was made genl. supt. of the Burton Stock Car Company at Wichita, Kans. In 1890 he accepted a position as master car builder of the Boston & Maine, which he has held up to the present time. Mr. Chamberlain was president of the Master Car Builders' Association in 1901 and 1902.

BOOKS.

The Slide Rule. A Practical Manual. By C. N. Pickworth. 104 pages. 5 x 7¼. Cloth. Illustrated. Published by D. Van Nostrand Co., 23 Murray Street, New York. Price, $1.00.

This is the tenth edition of this valuable book, which has been substantially revised in many parts and contains much new matter relating to special instruments of recent introduction. It is the most complete and elaborate work on this subject that we have seen and a perusal of its pages will show an unsuspected broad field of computation in which the slide rule can be used to great advantage.

Self Propelled Vehicles. A Practical Illustrated Treatise on Automobiles. Fifth revised edition, entirely rewritten. By James E. Homans. 5¼ x 8½. Cloth. 600 pages. Thoroughly illustrated. Published by Theo. Audel & Co., 63 Fifth Avenue, New York. Price, $2.00.

This book is a very complete treatise on the modern automobile and has been thoroughly revised to date.

Boiler Water. By William Wallace Christy. 235 pages. 6 x 9. Cloth. 77 illustrations. Published by D. Van Nostrand Co., 23 Murray Street, New York. Price, $2.00.

The title page of this book contains two very trite remarks to the effect that, "A steam boiler is a steam generator not a kettle for chemical reaction" and, "The only compound to put into a boiler is pure water." The book itself deals most exhaustively with the subject of boiler water for both locomotive and stationary use. It gives a number of tables showing the analysis of water taken from all parts of the country and carefully explains the proper method of treating the different kinds for the desired results. It also explains what results are desirable and what permissible. Taken altogether we can recommend this book most highly to any one interested in the water purification problem.

The Engineering Index. Edited by H. H. Suplee and J. H. Cuntz in cooperation with C. B. Going. Volume IV. 1901 to 1905. 1234 pages. 6½ x 9. Cloth. Published by the Engineering Magazine, 140 Nassau Street, New York. Price, $7.50.

This is the fourth volume of this very valuable work and covers the period from the year 1900 to the first of the year 1906. It covers all branches of engineering and clearly indexes and describes about 43,000 important articles and papers of permanent value which appeared in about 250 standard technical weekly, monthly and periodical journals, transactions and proceedings. All of this matter is presented in alphabetical order by subjects and is arranged for convenient and rapid reference. All of the articles on any particular subject or branch of work are grouped together under the proper heading, making it of exceptional value for the study or investigation along certain particular lines. For instance, the section on the subject of locomotives covers 36 pages and includes about 1500 separate articles, each of which is sufficiently described to give a clear idea of its scope. This work will be found to be practically invaluable in the working library of every mechanical office and of every engineer.

CATALOGS.

IN WRITING FOR THESE CATALOGS PLEASE MENTION THIS PAPER.

AMERICAN TURRET LATHE.—The Gisholt Machine Company, Madison, Wis., has sent out a small folder giving a general description of this lathe.

RAILROAD WATER SERVICE SPECIALTIES.—Descriptive literature from the Golden-Anderson Valve Specialty Company, Fulton Building, Pittsburgh, Pa., concerning the Anderson automatic and counterbalanced valve, adapted for all pressures, and especially designed for use in connection with railroad standpipes and tank service. Also a description of the Anderson patent float valve for controlling the water level in tanks or reservoirs. This company also has an altitude valve for maintaining a uniform stage of water in a tank and doing away with tank fixtures.

INDUCTION MOTORS.—The Allis-Chalmers Co., Milwaukee, Wis., is issuing bulletin No. 1040, which is a revised edition of the previous induction motor bulletin and is to be substituted for it in the loose leaf binder. The subject is handled in the same careful, complete, and at the same time concise, manner which characterizes the recent bulletins of this company. Matter is included on starting apparatus for polyphase induction motors and a few illustrations are given showing the application to pumps and other machinery.

VALVES AND PACKING.—Jenkins Bros., 71 John St., New York, is issuing an attractive catalog and price list, which shows many different designs of practically all types of pressure controlling

and regulating valves, as well as the large variety of packings handled by this company. Each separate design or kind of both valves and packing is illustrated and accompanied by a table giving sizes in which it can be furnished and the corresponding prices. One section of the book gives the important dimensions of each different design by means of outlined drawings. A price list of separate parts is also included.

TEN-WHEEL LOCOMOTIVES.—The fifth of the series of pamphlets which is being issued by the American Locomotive Company has recently been published. This pamphlet is devoted to 10-wheel type locomotives weighing less than 150,000 pounds, and will be followed shortly by another presenting the heavier designs of this type. The pamphlet illustrates and describes 21 different designs of 10-wheel locomotives ranging in weight from 64,000 to 150,000 pounds and adapted to a variety of road and service conditions. This series now includes pamphlets on the Atlantic, Pacific, Consolidation and 10-wheel types.

EMERY WHEELS AND GRINDING MACHINERY.—The Bridgeport Safety Emery Wheel Company, Bridgeport, Conn., is issuing an attractive catalog descriptive of grinding and polishing machinery, as well as the abrasive wheels for use thereon, which shows a very complete collection of different designs of this class of machinery. Tool grinders in many sizes for driving either by belt or motor, using either alternating or direct current, in both floor and bench designs, with one or two wheels, are very completely illustrated. Following these are many different arrangements and sizes of buffing lathes, as well as knife grinders in practically all sizes. Guide bar grinders, swinging frame grinders and other special designs are also included.

ELECTRICAL MACHINERY.—The General Electric Company issues under date of December, 1906, bulletins for binding in its loose leaf binder as follows: No. 4480, pipe thawing transformers; Bulletin No. 4469, which supersedes No. 4378, on pocket instruments for direct or alternating current; No. 4477, which supersedes No. 4326, on accessible manhole junction boxes; No. 4483, on automatic time switches; No. 4476 on type PP dial controllers; No. 4479, a complete description of the electrical equipment of the Toledo & Chicago Interurban Single Phase Railway, by John R. Hewitt; No. 4478, which supersedes No. 7560, on parts of type K series parallel controllers. These bulletins correspond in arrangement and scope to the previous issues of this character.

AIR AND GAS COMPRESSORS.—The Ingersoll Rand Company, 11 Broadway, New York, is issuing catalog No. 36 which confines itself to the subject of the Ingersoll-Sergeant air and gas compressors. These are made in nine classes, each of which is briefly described, accompanied by tables of sizes and illustrations of typical machines. In addition to being a very nicely arranged and well appearing catalog this book also contains much valuable engineering data for use in connection with air compressors, as well as two important articles, one on "Elements of Economy in the Straight Line and Duplex Types of Compound Air Compressors," which handles the subject in a very clear and convincing manner, and the other on "Compound Air Compression," which goes very deeply into the details of this subject. It contains 183 pages and will be found to be both interesting and valuable to all users of compressed air.

CALENDARS FOR 1907.— We beg to acknowledge receipt of attractive calendars as follows: From the Kennicott Water Softening Company a calendar which gives an excellent reproduction of Anglo Asti's famous painting "Thelma." This was one of the last and the greatest effort of this famous painter and was purchased by the late Charles Fair of San Francisco for $10,000. It is exceedingly fortunate that this reproduction was made before the catastrophe of last April, as the original painting was destroyed at that time.

The Crocker Wheeler Company is issuing a calendar showing a view, printed in colors, of the main office and works of the company. It is an excellent example of lithographic work and gives an impression of the magnitude and attractive surroundings of the Crocker-Wheeler works.

The Bangor & Aroostook Railroad is issuing calendars which include some very attractive reproductions, in colors, of camping scenes in the Maine woods. This company also publishes an interesting combined pamphlet and time table, which is profusely illustrated with scenes of points reached by its lines.

American Wood Working Machinery Co. is issuing a calendar in which the dates are in large numbers and each monthly sheet gives illustrations of different machines, totaling over 120, which are manufactured by it.

NOTES.

NATHAN MFG. CO.—This company announces that Mr. Charles R. Kearns, after an enforced absence of six years, due to illness, has again resumed his duties with it.

STANDARD COUPLER COMPANY.—Mr. George A. Post, Jr., has resigned his position as sales engineer with the Westinghouse Machine Company and accepted service as engineer representative of the Standard Coupler Company, 160 Broadway, New York.

RIEHLE BROS. TESTING MACHINE CO.—This company has been awarded the contract for a compression testing machine of 1,000,000 lbs. capacity for the Bureau of Surveys of the City of Philadelphia. It is to be installed in the testing laboratory of that city and will be used in making compression tests of building material, concrete, etc.

LOCOMOTIVE APPLIANCE COMPANY.—The election of officers of this company recently held, resulted as follows: Ira C. Hubbell, president; J. B. Allfree, consulting engineer; Clarence W. Howard, W. J. McBride and F. W. Furry, vice-presidents; and W. H. England, secretary and treasurer. This company also announces that Mr. H. H. Newson has been appointed sales agent.

CHICAGO PNEUMATIC TOOL COMPANY.—Mr. J. W. Duntley, president of the above company, who returned a short time ago from his twenty-first trip to England and the Continent in the interest of the pneumatic tool business, has again sailed for Europe for the purpose of closing up several important contracts. Mr. Duntley reports that the pneumatic tool business is on the increase at all points abroad.

INDEPENDENT PNEUMATIC TOOL COMPANY.—This company has been compelled by its largely increasing business to purchase a large four story brick building adjoining its plant at Aurora, Ill., which will give approximately 100,000 sq. ft. of additional floor space. A large amount of the latest improved machinery will be installed therein and it is expected that the company will be able to double its output in the coming year.

HEATING AND VENTILATING.—Among the installations of heating and ventilating apparatus now being installed by the B. F. Sturtevant Co., Hyde Park, Mass., are round houses for the Missouri Pacific Railway at Wichita, Kans.; Chicago Great Western at Red Wing, Minn., and the Northern Pacific at Dupo, Ill. The same company is also installing similar apparatus in the Dunkirk shops of the American Locomotive Co.

S. F. BOWSER & CO.—This company on account of its large increase in business during the past year has found it necessary to open a branch office in New York City. This office is located at 299 Broadway, and is in charge of Mr. W. F. Hatmaker. The company has also found it necessary to increase its factory at Fort Wayne by 125 per cent.; to build a new factory at Toronto and to add over sixty salesmen to its selling force.

QUINCY-MANCHESTER-SARGENT CO.—Mr. Howard M. Post has accepted the position of advertising manager with the above company. Mr. Post has had long experience in the advertising business and is thoroughly conversant with all its branches. He leaves a similar position with the Kellogg Switchboard and Supply Co., of Chicago, which he has successfully handled for a number of years, during which time there was issued a large amount of very fine catalog work, notably a beautiful 175 page Spanish edition of a general catalog.

GENERAL ELECTRIC COMPANY.—Mr. William J. Clark, general manager of the foreign department of the General Electric Company, has been appointed by Governor Hughes of New York as a delegate from that State to the National Convention for the Extension of Foreign Commerce of the United States, which will be held at Washington beginning January 14. Mr. Clark is thoroughly conversant with commercial conditions both at home and abroad and his book "Commercial Cuba" is recognized as an authority on the subject. He was a United States delegate to the International Railway Congress in 1905.